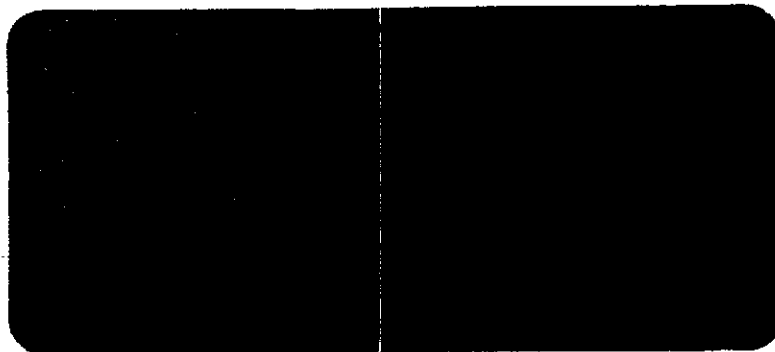


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HYDROSYSTEMS INC.

P.O. Box 348 Dunn Loring, Virginia 22027 (703) 573-1690

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WORK PLAN FOR THE
SUPPLEMENTAL REMEDIAL INVESTIGATION
AT THE U.S. TITANIUM SITE,
PINEY RIVER, VIRGINIA

REVISION NO. 2

PREPARED FOR:

AMERICAN CYANAMID COMPANY
ONE CYANAMID PLAZA
WAYNE, NJ 07470

PREPARED BY:

HYDROSYSTEMS, INC.
PO BOX 348
DUNN LORING, VA 22027

SEPTEMBER 12, 1986

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PREFACE

This document is submitted on behalf of American Cyanamid Company in compliance with the Stipulation and Order entered May 7, 1986, in the Circuit Court of Nelson County, Virginia, in the case of Commonwealth of Virginia v. United States Titanium Corporation, et al. (Chancery No. 1536). This document sets forth the work plan for conducting the Supplemental Remedial Investigation (SRI) at the U.S. Titanium site, Piney River, Virginia, in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP).

The data and analyses developed pursuant to this work plan will be incorporated into a formal SRI report and will be used to support the Feasibility Study (FS) and the Record of Decision (ROD). The formal SRI report may incorporate, by reference, data and/or conclusions presented in prior studies.

HYDROSYSTEMS, Inc. has been retained by American Cyanamid Company to conduct the SRI. HYDROSYSTEMS, Inc. was established in 1984, bringing together key personnel with over 20 years of experience in environmental sciences and engineering. The senior staff of HYDROSYSTEMS, Inc. has been involved in several CERCLA sites, on behalf of both the U.S. Environmental Protection Agency as well as private parties. In addition, its staff has experience in the assessment and remediation of acidic-leachate producing landfills and coal mines of a nature similar to the U.S. Titanium site.

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1.0 INTRODUCTION

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1.1 SITE DESCRIPTION

The U.S. Titanium site is located in Nelson County, Virginia, on the north side of the Piney River and east of Virginia Route 151 about 40 miles south of Charlottesville, Virginia (see Figure 1.1). This work plan addresses an area of about 90 acres on the northeastern portion of the former plant property (outlined by bold lines on Figure 1.1). The center of the study site is located approximately at 37° 42' 30" north latitude and 79° 01' 00" west longitude. The site is located on the Piney River Quadrangle 7.5 minute series topographic map (U.S. Geological Survey, 1963).

The site is located in the Piedmont physiographic province about five miles east of the Virginia Blue Ridge. In the general vicinity, elevations range from 2218 feet (datum is mean sea level) at England Ridge 4.5 miles to the northwest of the site to just under 600 feet about one mile downstream of the site on the Piney River. Within the boundaries of the site, the elevation ranges from 726 feet near the northwest corner of the site to about 620 feet along the north bank of the Piney River near the southeast corner of the site.

The SRI encompasses seven distinct areas within the site boundaries, as well as potentially contaminated groundwater. These areas are described below in Section 1.3.

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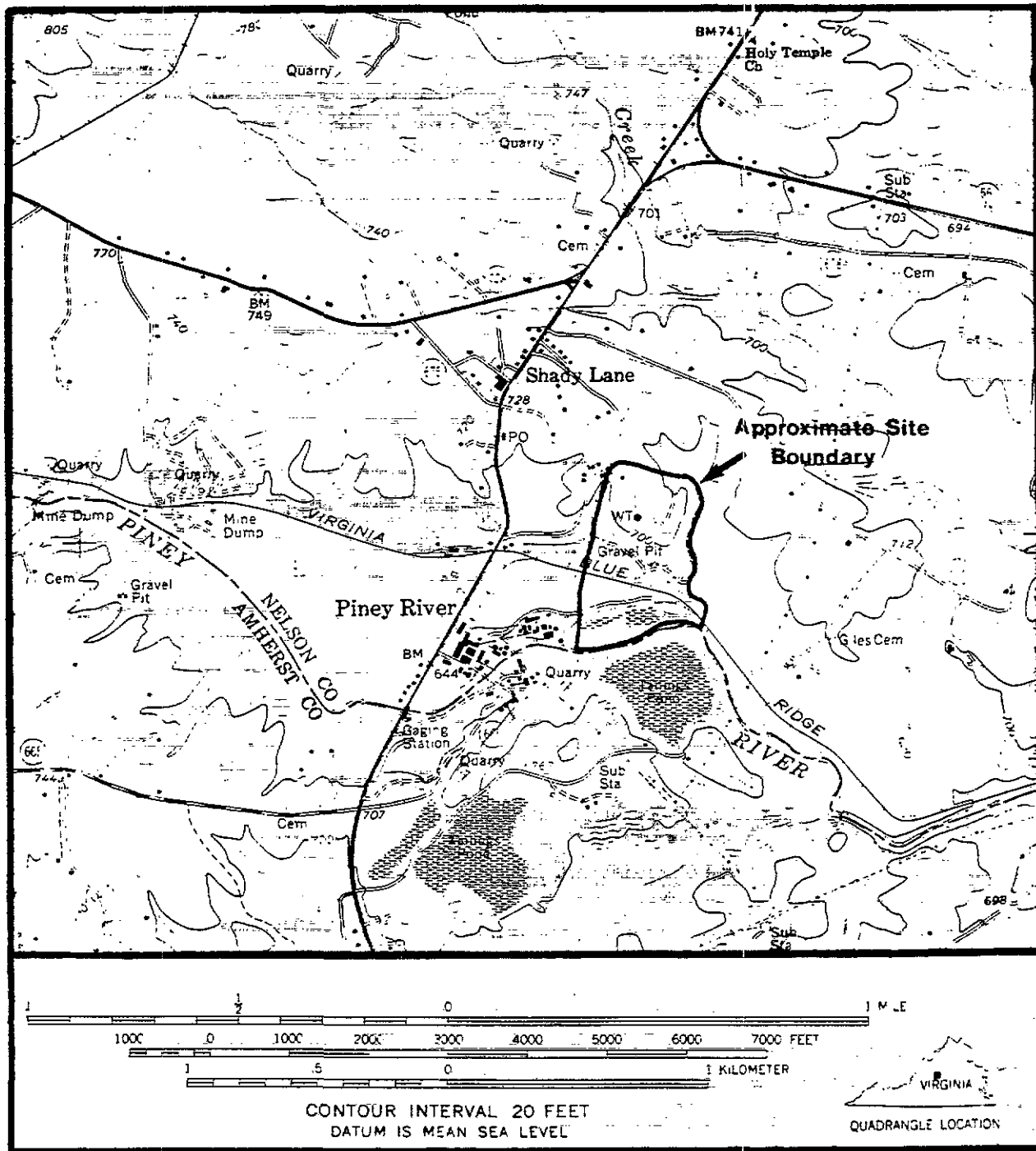


Figure 1.1. Location map for the U.S. Titanium site in Piney River, Virginia.

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1.2 SITE HISTORY

Operations at the site commenced in 1931 under the ownership of the Virginia Chemical Corporation. Those operations included: (1) the production of titanium dioxide pigment from native ilmenite ore via the sulfate process and (2) production of phosphate from native apatite ore.

In July of 1944, American Cyanamid Company acquired the plant and property. American Cyanamid Company operated the plant for the production of titanium dioxide only.

As a result of the titanium dioxide and phosphate operations, the plant produced a waste stream consisting of dilute sulfuric acid, hydrated ferrous sulfate (copperas), diatomaceous earth filter cake, gypsum (from the phosphate process only), and unreacted apatite and titanium ore. From 1931 until 1947, the wastewater stream was discharged directly to the Piney River.

In 1947, American Cyanamid Company constructed a settling pond to remove settleable solids from the wastewater (NUS, 1983, p. A-2). In April of 1947, the State Water Control Board (SWCB) issued to American Cyanamid Company, pursuant to Section 1514-b17 of the State Water Control Law, Waste Discharge Certificate No. 34 for the Piney River plant effluent (NUS, 1983, p. 2-7).

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In the early 1950's, American Cyanamid Company employed partial neutralization of the wastewater, and by 1955 had eliminated suspended solids from the effluent and reduced sulfuric acid discharges from 120 tons/day to 90 tons/day (NUS, 1983, p. 2-11). This was followed by the installation of a neutralization lagoon which became operational in 1957 (NUS, 1983, p. A-5).

By 1961, American Cyanamid Company had achieved the following results:

1. All wastewater was neutralized to at least a pH of 5.
2. Flow and pH monitoring equipment were installed on the effluent stream.
3. A sulfuric acid recovery plant was in continuous operation to reduce sulfuric acid discharges. (NUS, 1983, p. 2-12)

On March 21, 1961, the SWCB issued to American Cyanamid Company Waste Discharge Certificate No. 1312 in replacement of Certificate No. 34 for the Piney River plant effluent. This new discharge certificate was issued to reflect improvements instituted by American Cyanamid Company in the waste handling operations. (NUS, 1983, p. 2-8)

In 1971, American Cyanamid Company closed down all operations at the Piney River plant. Also in 1971, American Cyanamid Company commissioned a study of the acidic discharges from the copperas stockpile where an estimated 80,000 cubic yards of copperas had been stockpiled between 1949 and 1971 (NUS, 1983, pp. ES-1 and 2-6).

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The study, conducted by Geraghty & Miller, Inc., concluded that acidic discharges could be minimized by removing the copperas to a new clay-lined landfill on the south side of the Piney River (Geraghty & Miller, Inc., 1972).

On October 31, 1972, American Cyanamid Company submitted plans to the SWCB for removal and burial of the copperas in a new landfill to be located on the south side of the Piney River (NUS, 1983, p. 2-8). On April 5, 1973, American Cyanamid Company obtained approval from the Executive Secretary of the SWCB for the plan to rebury the copperas in the proposed new landfill (NUS, 1983, p. 2-8).

In 1973, Mr. S. Vance Wilkins purchased the property from American Cyanamid Company. As part of the sales agreement, American Cyanamid Company paid Mr. Wilkins \$100,000 for the stipulated purpose of implementing the State-approved plan for burial of the copperas on the south side of the Piney River (NUS, 1983, p. 2-3).

Mr. Wilkins constructed a SWCB-approved temporary leachate collection and recirculation system consisting of a lower collection lagoon, an upper retention pond, and a pumping system for transferring the leachate from the lower collection pond to the upper retention pond. The SWCB issued a three-year duration State No Discharge Certificate No. IW-ND-407 on December 23, 1974, to permit operation of the temporary leachate collection and recirculation system installed by Mr. Wilkins until a permanent solution to the problem was found (NUS, 1983, p. 2-8 and personal communication with Ted Jett, SWCB).

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In March of 1976, Mr. Wilkins sold a portion of the property north of the Piney River to the U.S. Titanium Corporation, retaining ownership of that part of the property on the south side of the river and portions of the property on the north side. U.S. Titanium Corporation's purchase of the Piney River property was financed by The Stone Foundation, which obtained a mortgage on the property.

In September of 1977, the SWCB ordered U.S. Titanium Corporation to submit a plan for disposal of the copperas. U.S. Titanium Corporation failed to submit the required disposal plans, and the SWCB filed suit in the Circuit Court of Nelson County to obtain a temporary injunction which required U.S. Titanium Corporation to apply for a landfilling permit for the copperas from the State Department of Health. (NUS, 1983, p. 2-9)

After further judicial proceedings, U.S. Titanium Corporation and/or The Stone Foundation contracted with Geonics, Inc. to prepare a permit application for disposal of the copperas. This application was submitted to the SWCB and State Department of Health on October 3, 1979 and approved by the State Department of Health on March 11, 1980. (NUS, 1983, p. 2-9)

By May 30, 1980, U.S. Titanium Corporation and/or The Stone Foundation completed the burial of copperas in a test cell, and, on October 2, 1980, New Enterprise Construction Company began full-scale burial of the copperas under contract to U.S. Titanium Corporation and/or The Stone Foundation. Burial was completed on December 12, 1980, and final

grading, channel improvements, and seeding and mulching were completed by January 16, 1981. (NUS, 1983, p. 2-13)

During the U.S. Titanium Corporation and/or The Stone Foundation sponsored burial of the copperas, the U.S. Environmental Protection Agency, Region III (EPA), contracted with Ecology and Environment, Inc. to conduct a preliminary assessment of the U.S. Titanium site. The resulting report was submitted to the EPA on August 3, 1980 (NUS, 1983, p. 2-13).

On April 7, 1982, the Executive Director of the SWCB disapproved a site improvement plan submitted by U.S. Titanium Corporation and/or The Stone Foundation. As a result, Benton G. Tinder was appointed receiver of the U.S. Titanium Corporation property at Piney River (NUS, 1983, p. A-12). On May 27, 1982, Mr. Tinder contracted with R.M. Cash and G. Burley of Amherst, Virginia, to complete reclamation and runoff control for the former copperas stockpile area. This reclamation work was funded from the Governor's Contingency Fund. (NUS, 1983, p. 2-10)

In December 1982, the EPA ranked the U.S. Titanium site 332nd out of 418 sites on the National Priorities List published pursuant to Section 105(8)(B) of CERCLA (NUS, 1983, p. 2-11). On February 1 and 2, 1983, NUS Corporation, under contract with the EPA, conducted a site inspection as part of the development of a Remedial Action Master Plan (RAMP). The RAMP was released in August of 1983. (NUS, 1983, pp. A-13 and 1-1)

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In June of 1983, the SWCB authorized the Department of Civil Engineering, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, to conduct studies relating to the U.S. Titanium site (VPI, 1984, p. 1).

In 1985, EPA contracted with GCA Corporation to conduct a focused feasibility study (FFS) on the nature and extent of the acidic discharges from several specific areas on the site and evaluate alternative remedial actions. On October 8, 1985, the EPA released a draft FFS prepared by GCA Corporation dated July 23, 1985.

In early 1986, the U.S. Titanium Corporation sold their Piney River property to the P.R. Corporation of Piney River, Virginia. One of the principals of the P.R. Corporation is Mr. Robert Desmond.

On April 30, 1986, the Attorney General for the Commonwealth of Virginia and American Cyanamid Company signed a Stipulation and Order establishing a schedule for completion by American Cyanamid Company of a temporary source control action for the copperas burial pit, a Supplemental Remedial Investigation, and a Feasibility Study for the U.S. Titanium site. This work plan is submitted pursuant to that order which was entered by the Circuit Court of Nelson County, Virginia, on May 7, 1986.

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1.3 STUDY AREAS

The areas that will be studied in this SRI are delineated in Figure 1.2, and described below:

- o Area 1 - The copperas burial pit was constructed in 1980 by the U.S. Titanium Corporation and/or The Stone Foundation. The amount of copperas placed in the burial pit has been estimated previously to be 80,000 cubic yards, apparently on the basis of the number of truck loads reportedly hauled to the pit (personal communication with T. Jett, SWCB). The amount of soil-copperas mixture that is currently in the burial pit was estimated recently to be 40,000 cubic yards (HYDROSYSTEMS, 1985, p. 25). Area 1 has a surface area of approximately four acres.
- o Area 2 - The reclaimed slope to the east of the burial pit was the original, above ground storage area for the copperas stockpile. During the 1981 remedial actions, the originally stockpiled copperas was removed from Area 2 and buried in Area 1. Area 2, covering approximately eight acres, was reclaimed by applying municipal sludge and agricultural limestone (aglime) followed by revegetation.
- o Area 3 - This area contained the retention pond built by Mr. S. Vance Wilkins, which was part of a leachate collection and recirculation system operated between 1974 and 1980 (personal communication with Ted Jett, SWCB). The retention pond, covering an area of approximately 1.5 acres, received leachate-contaminated runoff.

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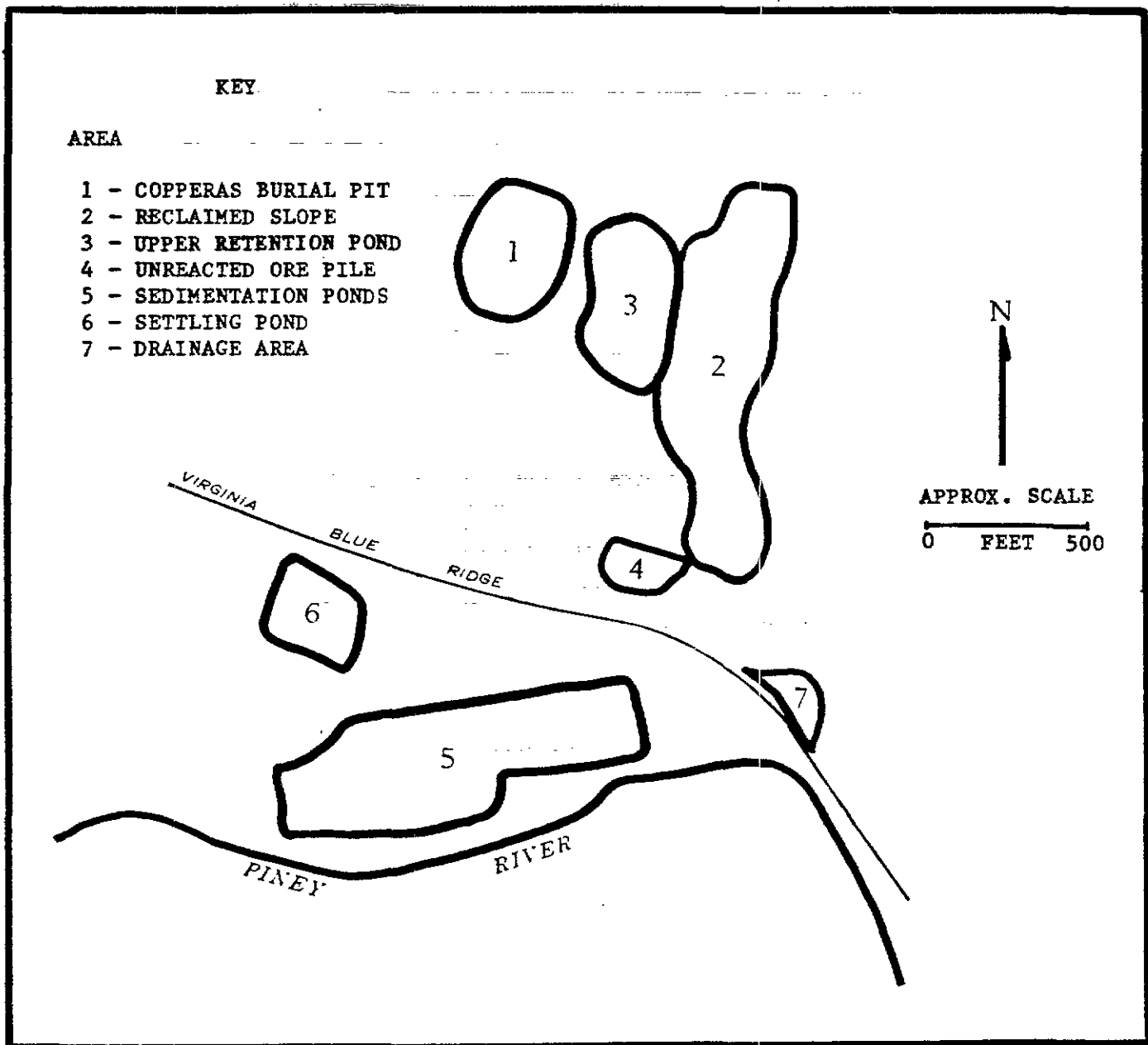


Figure 1.2. Site map for the U.S. Titanium site, Piney River, Virginia, showing the approximate boundaries of the disposal areas addressed by this work plan.

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- o Area 4 - This area at the south end of the reclaimed slope appears to contain coarse grained, unreacted ore. Area 4 covers about one acre with the south slope of the material forming a cliff where excavation has occurred. This material reportedly originated from the reaction vats used in the titanium dioxide process (personal communication with S.A. Lamanna, former American Cyanamid Company employee at Piney River).
- o Area 5 - The sedimentation ponds next to the river were used to remove settleable solids from the wastewater prior to being discharged to the Piney River. The sedimentation ponds appear to contain an extremely fine-grained sediment composed of unreacted ore (mainly ilmenite and rutile) and a filter cake composed of diatomaceous earth. The sedimentation ponds also may contain gypsum that remained from the operations of the Virginia Chemical Corporation (personal communication with S.A. Lamanna, former American Cyanamid Company employee at Piney River). The sedimentation ponds cover an area of approximately 6.9 acres (VPI, 1984, p. 15).
- o Area 6 - The settling pond located between Area 1 and the Virginia Blue Ridge Railroad covers about one acre. The pond reportedly was used to settle and reclaim apatite, the phosphate ore, during the period the site was owned by the Virginia Chemical Corporation (personal communication with S.A. Lamanna, former American Cyanamid Company employee at Piney River).

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- o Area 7 - The drainage area, located in the southeast corner of the site near EPA well no. 2 on the north side of the Virginia Blue Ridge Railroad, covers about 1.5 acres (VPI, 1984, p. 16). The sediments in the drainage area consist of clay (Morris, 1984) apparently deposited primarily from erosion of Area 2. Erosion of the reclaimed slope during reclamation in 1981 may have contributed large volumes of sediment to this area (HYDROSYSTEMS, 1985, p. 5).
- o Groundwater - An unknown amount of acidic leachate has migrated downward into the groundwater flow system. The general flow of groundwater is reported to be towards discharge points along the Piney River (VPI, 1984, p. 10). Groundwater may discharge into the ditch north of the railroad (near wells 1 and 2) during times of high water-table conditions. In addition, groundwater beneath the burial pit locally may flow toward the east and southeast, discharging into the drainage ditch at the base of the reclaimed slope (Area 2). It appears that all groundwater ultimately discharges to the Piney River (HYDROSYSTEMS, 1985, p. 2).

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2.0 PROJECT OVERVIEW

The purpose of the Supplemental Remedial Investigation is to augment the existing data base relating to the nature and extent of the acidic discharges at the U.S. Titanium site in Piney River, Virginia. Several studies related to the site have been completed previously. These studies include:

- a. NUS. 1983. Remedial Action Master Plan, U.S. Titanium Site, Nelson and Amherst Counties, Virginia. prepared for the U.S. Environmental Protection Agency, contract no. 68-01-6699.

The focus of this study was to provide a compilation of existing data on the site and environmental conditions and provide a general planning document and site management tool for the design of subsequent remedial investigations, feasibility studies, and remedial actions. The report provides a fairly comprehensive history of the site.

- b. VPI. 1984. A Study of the U.S. Titanium Site in Nelson County, VA. Department of Civil Engineering, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

This report was authored by Dr. John Novak of VPI and was based on data collected by graduate students for Master of Science in Sanitary Engineering (see Morris, 1984 and Moslehi, 1984). Although the report presents a comprehensive appendix of data on groundwater and surface water quality, laboratory

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permeability tests, leaching tests and boring logs from Moslehi (1984), interpretation of the data is limited.

- c. Morris, M.S. 1984. Evaluation of the Hazardous Waste Site at the U.S. Titanium Plant in Piney River, Virginia. Master's Thesis, Department of Civil Engineering, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

This study was intended as an assessment of the environmental damage caused by the copperas waste. Field data included observations from the same three trenches referenced in Moslehi (1984), one trench in Area 5, the sedimentation ponds, analysis of groundwater samples obtained on several dates from the five EPA monitoring wells and six State monitoring wells, three samples of leachate from the copperas burial pit, soil samples from 56 hand-augered borings in Areas 2, 5, and 7, and analysis of samples from the Piney River for several dates.

- d. Moslehi, J. 1984. Investigation of a Clay Lined Storage Pit. Master's Thesis, Department of Civil Engineering, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

This study focused on Area 1, the copperas burial pit. The objectives of the study were to delineate the pit geometry and liner system, assess the characteristics of the natural soils and waste, and evaluate the degree of contamination of the subsoil around the pit. Thirteen test borings ranging from 10

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to 60 feet were installed. Eleven borings were in and near the burial pit while two borings were in Area 2, the reclaimed slope. Three test trenches also were excavated in the side of the burial pit. The boring program did not adequately define the extent of the burial pit or the amount of copperas buried there. The results do provide data on the engineering properties of the soil and copperas and insight into the mechanisms of failure of the burial pit.

- e. GCA. 1985. Endangerment Assessment/Feasibility Study: U.S. Titanium Site, Piney River, Virginia. Revised draft final report. Prepared for the U.S. Environmental Protection Agency, Contract no. 68-01-7037.

This draft report presents the results of a focused feasibility study, including an endangerment assessment and evaluation of alternative remedial actions for Areas 1 through 5. The study relied on existing data only.

Numerous data gaps have been identified in the previous studies. Several of these data gaps are of major importance to the understanding of the extent of the problem, while other data gaps are important to the evaluation of alternative remedial actions. No evaluation of the hydrogeology has been completed. The hydrogeologic evaluation should include a hydrologic budget, water table map, groundwater flow directions, and characterization of aquifer permeability. The previous site work has not provided a comprehensive investigation of the surface water and groundwater quality impacts. No previous work has been

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conducted to estimate the relative contribution of each source to the contamination of surface- and groundwater. The previous studies have not described the pathways of contamination or the geochemical controls on leachate production and migration.

Therefore, the present investigation is intended to supplement the previous studies by filling in these gaps in the existing data base. The field work will involve water-quality measurements of the Piney River, groundwater, and site runoff. The sources of contamination will be delineated utilizing a soil boring program in areas of known and suspected contamination. Contaminant migration in groundwater will be described utilizing measured water levels and contaminant concentrations obtained from existing and temporary wells.

In order to better understand and quantify the impact acidic discharges are having on the Piney River, a water-quality monitoring program for the Piney River has been designed. This program includes the field measurement of pH and specific conductance at six sampling stations located in the river. Of the six stations, one is upstream of the site, four are adjacent to the site, and the sixth is 1000 feet down stream (see Appendix C, Sampling Plan). Water samples will also be collected at each river sampling station for laboratory measurement of total dissolved iron.

Water samples collected from on-site monitoring wells and surface drainage will be analyzed for pH and specific conductivity in the field; and total dissolved iron, and sulfate in the laboratory.

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Additionally, a soil boring program will be utilized to collect solid waste and soil samples from the site. Samples collected from the copperas burial pit will be analyzed for copperas content. Soils collected from Areas 1, 2, and 3 will be analyzed for nutrient content and pH by the Virginia Cooperative Extension Service lab at Blacksburg. Solid waste samples will be collected from Areas 4 and 6 to determine their acid-producing potential.

2.1 IDENTIFICATION OF DATA REQUIREMENTS

General data requirements for the completion of the Supplemental Remedial Investigation at the U.S. Titanium site are as follows:

- A. Characterization of the extent and nature of the contamination in each of the seven areas and in groundwater.
- B. Characterization of the hydrogeology to provide data for evaluation of significance of the groundwater contamination component to acidic discharges and for the evaluation of effects of alternative remedial actions on mitigating groundwater contamination.
- C. Periodic monitoring of total dissolved iron, specific conductivity, and pH in the Piney River.
- D. Characterization of the effects of a storm runoff event from the site on pH, specific conductivity, and total dissolved iron in the Piney River to provide insight into nature and variation in site discharge quality.

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E. Characterization of groundwater and site runoff quality to provide data for the evaluation of alternatives.

2.2 STUDY OBJECTIVES

The ultimate objectives of the Supplemental Remedial Investigation are:

- o To quantify the extent and nature of contamination at the site;
and
- o To characterize the transport mechanisms and pathways of contamination from the site.

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3.0 REMEDIAL INVESTIGATION SCOPE OF WORK

3.1 TASK 1 - PROJECT OPERATIONS PLAN (POP)

The management of the Supplemental Remedial Investigation will be in accordance with the requirements of the EPA for investigations carried out under the NCP. The components of the POP include:

1. Quality assurance plan (see Appendix B);
2. Sampling plan (see Appendix C);
3. Health and safety (see Section 3.10);
3. Site management (see Section 5.0)
5. Data management (see Section 3.8)
6. Community relations plan (to be developed and instituted by the U.S. Environmental Protection Agency, Region III (EPA-III) per verbal instructions of Carol Stokes, who has been replaced by Michael Bass).

3.2 TASK 2 - DESCRIPTION OF CURRENT CONDITIONS

The current conditions at the site will be described, including, but not limited to:

1. Site background, including changes in ownership;
2. Previous studies, including a summary of existing data;
3. Present nature and extent of problem;

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4. History of response actions, including any recent source control measures.

3.3 TASK 3 - SITE INVESTIGATION

The site investigation includes the subtasks described in the following sections.

3.3.1 Boring Program for Area 1

A soil boring program to investigate the quantity and form of copperas buried in Area 1 will be completed. Seventeen borings with depths of approximately 15 feet will be utilized to accomplish this task. The borings, approximately located in Figure 3.1, will be continuously sampled by split-spoon and will be visually described in a log as to color, texture, relative moisture content, and visual content of copperas. Representative samples will be collected for laboratory analysis of copperas content.

Water-level measurements will be obtained on selected borings to determine the height of mounding within the buried waste at the time the borings are drilled.

Five one-foot deep, hand-augered soil samples will be collected on the west side of Area 1 in the vicinity of acidic seeps for soils analysis to determine requirements for revegetation. The approximate locations of these borings are shown in Figure 3.1; however, final locations may vary due to field conditions. Soil samples will be submitted to the

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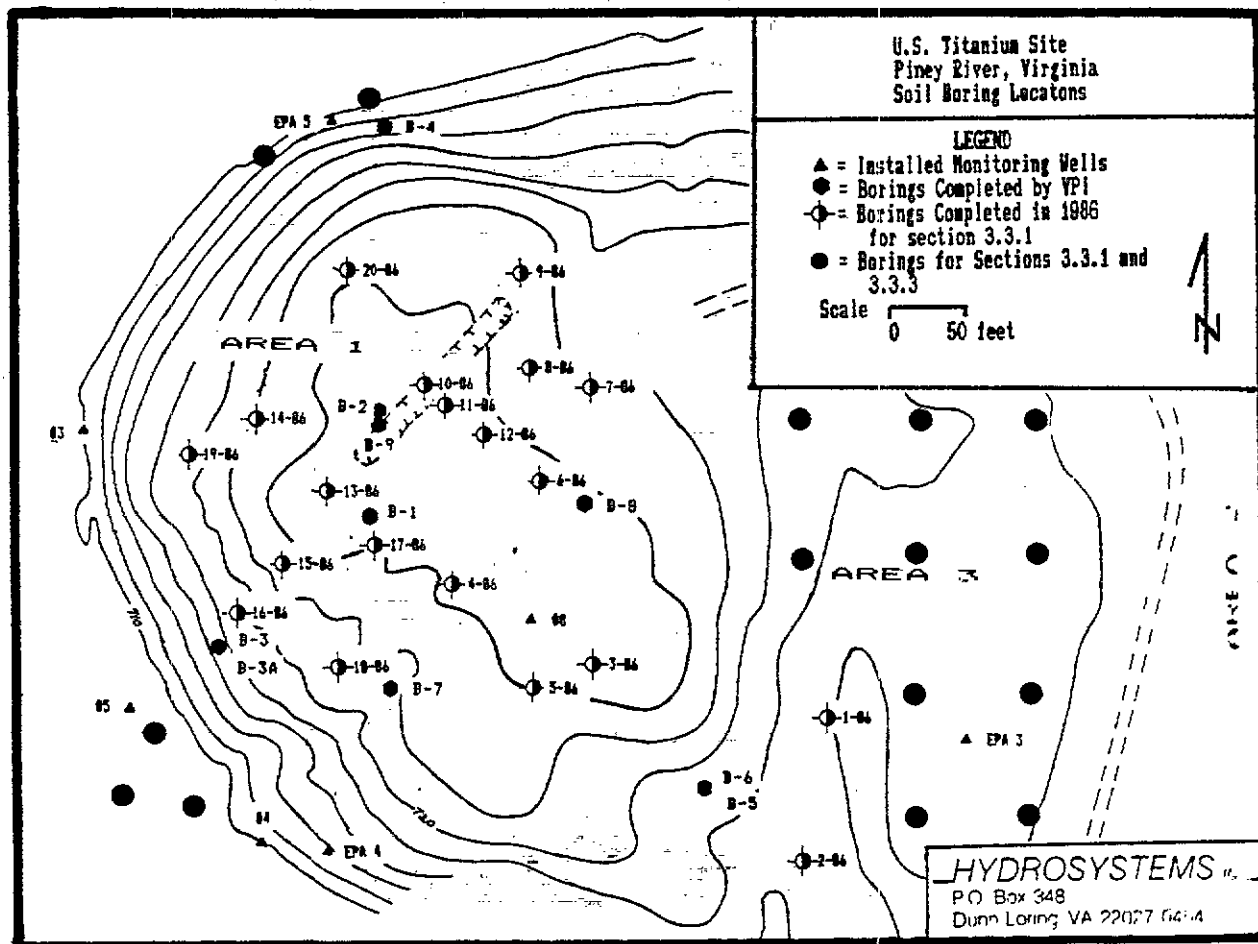


Figure 3.1. Approximate locations of test borings in Areas 1 and 3.

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Virginia Cooperative Extension Service, Blacksburg, Virginia for analysis of soil pH and nutrient content to determine fertilization and liming requirements.

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3.3.2 Investigation of Soils in Area 2

Hand-augered soil samples will be collected in Area 2 for soils analysis to assess a revegetation program and investigate requirements for remediating the drainage channel. Fifteen borings will be completed at the approximate locations shown in Figure 3.2. However, final locations of these borings may vary due to field conditions and due to the fact that both vegetated and unvegetated soils will be sampled. The borings will be completed to a depth of about one foot to obtain soil samples at a density of at least two per acre. Soil samples will be sent to the Virginia Cooperative Extension Service for analyses as described in Section 3.3.1.

3.3.3 Boring Program for Area 3

A soil boring program will be conducted to investigate the requirements for revegetating Area 3 and determine the possible presence of original copperas waste which may have been disposed in Area 3. Two borings drilled in the Spring of 1986 to depths of 10 and 6.5 feet in areas that appeared to have the deepest disturbed soil zones indicated that natural soil was encountered at depths of 5 and 4 feet, respectively (see borings 1-86 and 2-86 in Figure 3.1 for approximate locations).

To further investigate the potential presence of pure copperas that may have been disposed in Area 3, an additional ten hand-augered borings

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will be completed at the approximate locations shown in Figure 3.1. The final locations of the hand-augered borings may vary from the locations shown in Figure 3.1 due to field conditions. These hand-augered borings will be approximately four feet deep, since the previous two borings showed natural soil at from 4 to 5 feet depth.

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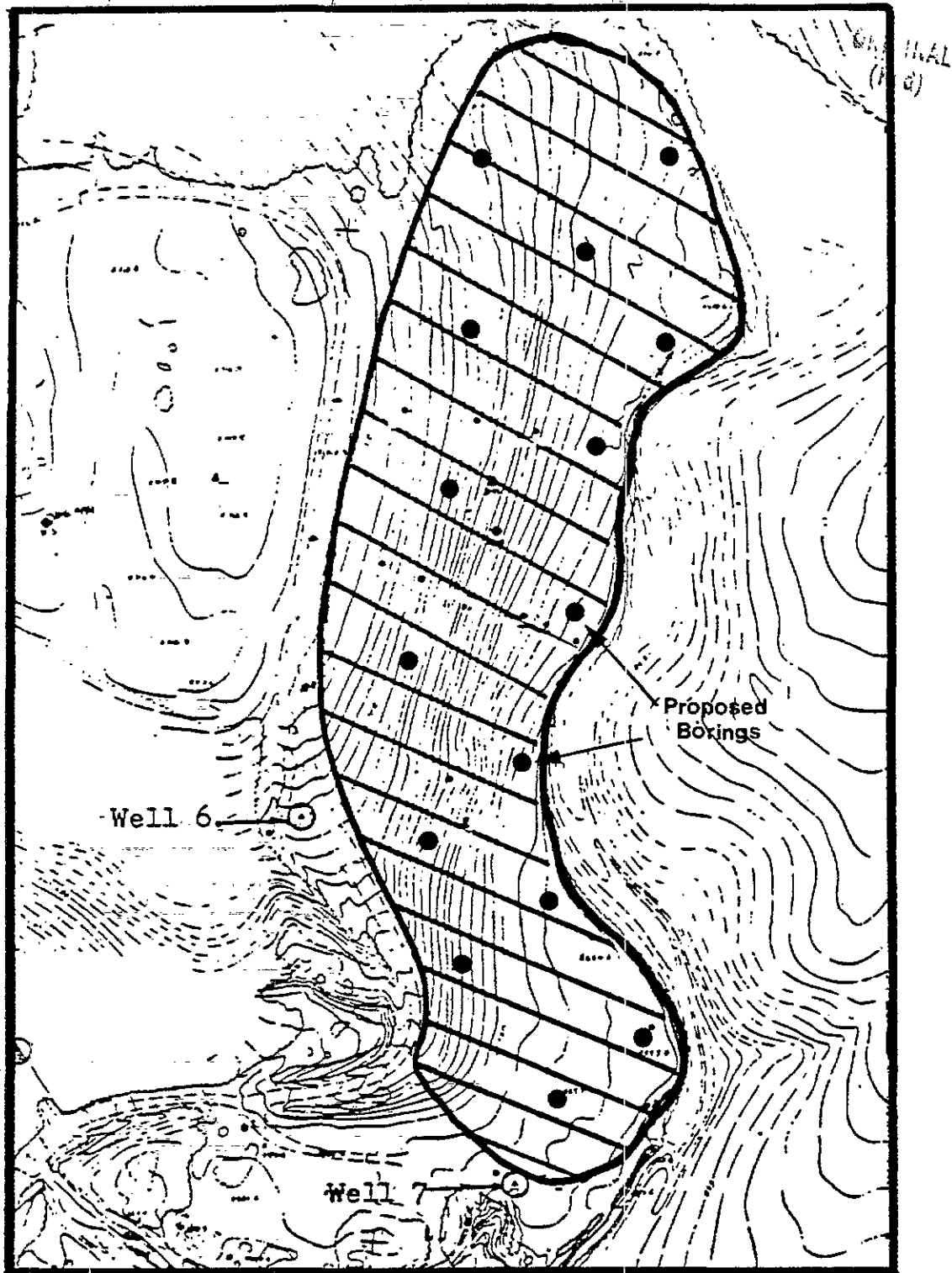


Figure 3.2. Approximate locations of hand-augered borings in Area 2.

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3.3.4 Characterization of Areas 4 and 6

An investigation of Areas 4 and 6 will be conducted to determine the composition and properties of the materials that are contained within these areas. These analyses will be used to determine if Areas 4 and 6 represent significant sources of contamination. Samples of the material will be collected utilizing three hand-augered borings in each area. The approximate locations of these borings are shown in Figure 3.3. The final locations of these borings may vary due to field conditions.

Area 4 is a storage pile of coarse-grained, unreacted ore forming an embankment. It is proposed that two borings be located on the top of Area 4 and one boring on the side-slope of Area 4. Six-foot borings will be of sufficient depth to allow characterization of the material, which on the surface appears fairly homogeneous.

Area 6 is an abandoned settling pond for reclaiming apatite ore. Residual ore in the bottom of the pond reportedly was excavated sometime after 1971 (a large breach in the dike is evidence of excavation activity). Presently, Area 6 contains a freshwater pond with abundant aquatic fauna and flora. This freshwater pond apparently represents intersection of the shallow water table. Considering the probable excavation of the pond, the presence of the freshwater pond, and the shallow water table, it is likely that no contamination currently exists in Area 6. Based on the apparent construction of the pond and dikes, i.e., the dikes are built up from the natural ground surface, and the shallow water table that is within a few feet of the surface, it is unlikely that disposal activities occurred at a depth greater than a few

feet below ground surface. Therefore, six-foot borings are considered adequate to characterize the potential for Area 6 to produce acidic leachate.

The collected samples will be analyzed for potential to produce acidic leachate. For Area 6, the sampling and analysis program will be integrated with the results of analyses to be made available by Dr. John Novak, VPI, Blacksburg, Virginia.

3.3.5 Area 5 Investigation

A field investigation will be conducted to develop the necessary data to characterize the contribution of acidic discharge via ground- and surface water to the Piney River from Area 5. Analyses of the field data will be used to:

1. Develop a hydrologic budget for the sedimentation ponds (Area 5) including direct runoff, infiltration, subsurface inflow of groundwater into the sediment, and subsurface outflow from the sediment. (See section 3.4.1.5 for explanation of the water budget.)
2. Quantify the rate of acidic loadings to the Piney River via both direct surface runoff and subsurface outflow. The acidic loadings will be calculated by using the estimates of direct runoff and subsurface outflow from beneath the ponds determined pursuant to paragraph no. 1 above and the estimates of average pH based on groundwater and runoff measurements.

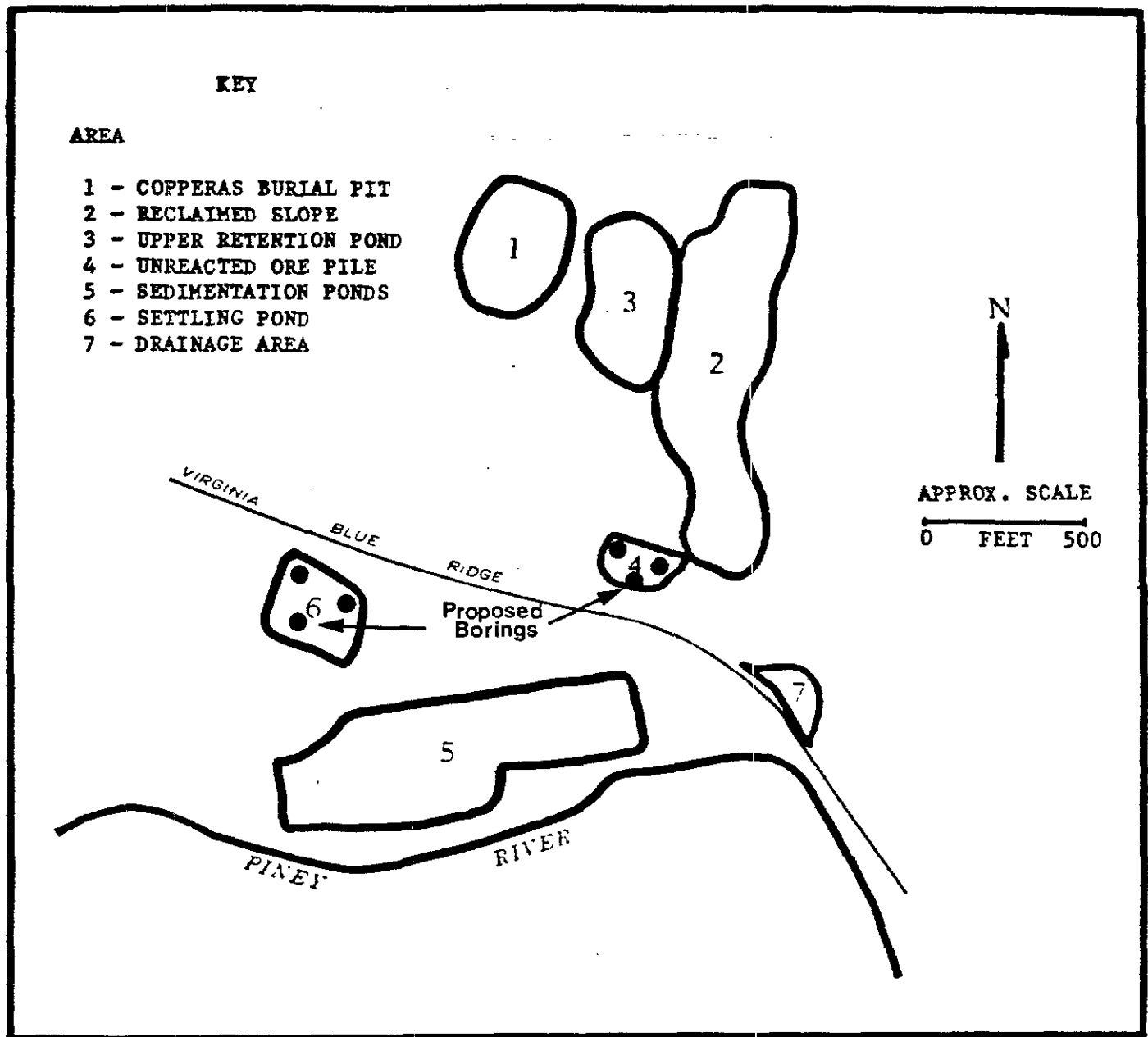


Figure 3.3. Approximate locations of hand-augered borings in Areas 4 and 6.

3. Evaluate possible underflow of already contaminated groundwater originating upgradient (to the north) of the ponds.
4. Evaluate the relative importance of each of the possible sources of acidic water in Area 5.

The following field activities will be conducted to develop the supporting data for these analyses.

- a. Along a transect running through well EPA #1, perpendicular to the river, install three temporary monitoring wells via hand auger. On a second transect about 500 ft to the west of EPA #1, install four temporary monitoring wells via hand auger. On each transect, three temporary monitoring wells will be in the ponds and one upgradient (to the north) of the pond.

On the east side of the sedimentation pond, install two hand augered temporary monitoring wells to obtain water levels in an area not affected by the sedimentation ponds. Figure 3.4 shows the approximate locations of the nine temporary monitoring wells for Area 5. The final locations of these temporary wells may vary due to field conditions.

The objectives of these wells are to develop profiles of the water table across Area 5, determine if the water table is mounded into the sediment, measure the field permeability, and obtain samples of groundwater for analysis of pH and specific conductivity. The purpose of collecting these data is to

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provide input into calculation of hydrologic budget and acidic loadings to the Piney River from Area 5.

Temporary wells are proposed for Area 5 because subsequent remedial actions will destroy any and all structures placed in and near the sedimentation ponds.

- b. Survey elevations of well casing tops.
- c. For both wet and dry seasons, measure water-table elevations in each well and construct areal contour map and cross-sections along each transect of the water table in Area 5.
- d. Collect samples of groundwater from each well for determination of field pH and conductivity.
- e. Conduct aquifer tests on each well to determine permeability of the sediment in the sedimentation ponds and flood plain (see Appendix B for description of method).
- f. Conduct surface infiltration test to estimate infiltration rates (see Appendix B for description of test method).
- g. Using data from hand borings installed during this study and previous studies (unpublished data to be made available by Dr. John Novak, VPI, Blacksburg, Virginia), estimate the thickness of sediment in the pond that is in contact with the water table.

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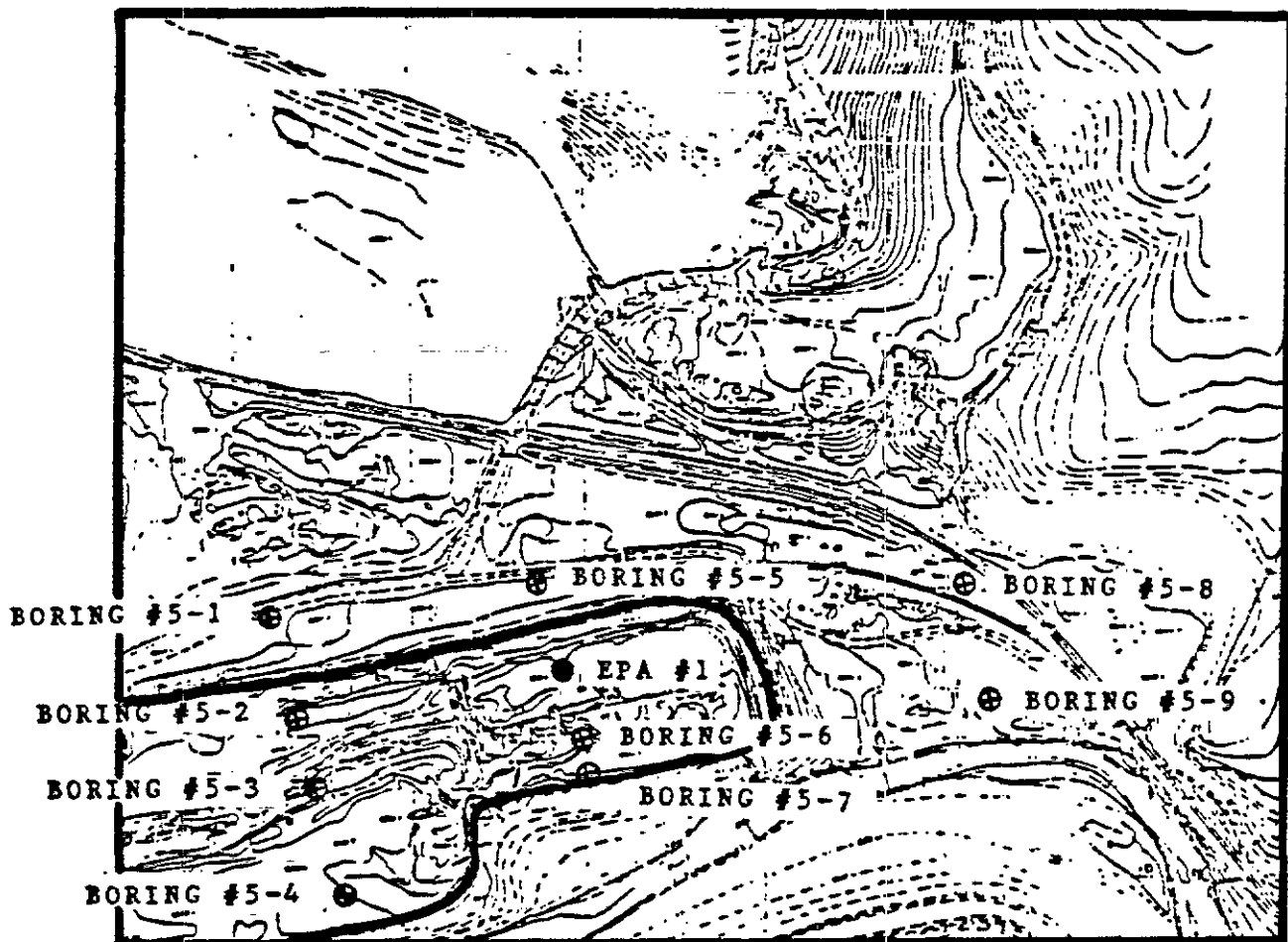


Figure 3.4. Approximate locations of temporary monitoring wells located in Area 5.

3.3.6 Site Hydrogeology

An analysis of the hydrogeology of the site will be completed utilizing the existing wells, data collected by other parties, and information from several shallow hand-augered borings. This task involves:

- a. The existing wells will be surveyed as to location and elevation.
- b. On at least two occasions, water levels within the wells will be measured and water samples collected for the analysis of pH, specific conductivity, sulfate, and total dissolved iron. At a minimum, water levels and samples will be collect during a wet and a dry season, i.e., Spring and Fall. These sampling times will provide the extremes for water-table elevation.
- c. Aquifer tests will be conducted on each well to determine the transmissivity and estimate hydraulic conductivity (see Appendix B for description of aquifer test method).
- d. In the areas previously identified as potentially suitable for installation of French drains (HYDROSYSTEMS, 1985, pp. 92-93), six hand-augered borings will be utilized to sample groundwater and soils. These borings will allow the determination of the depth to water table, the permeability of the aquifer, the pH, sulfate, and total dissolved iron content of groundwater, and depth to bedrock (only for purposes of costing the French drain installation--if depth to bedrock is greater than about six feet, bedrock has no effect on cost). The approximate locations

of these borings are shown on Figure 3.5; however, their final locations may vary due to field conditions. Permanent wells are not proposed because subsequent remedial actions will necessitate destruction of all structures in these areas.

- e. The necessity of additional groundwater monitoring wells will be evaluated based on the relationship between source areas, groundwater flow directions, and existing monitoring well locations. EPA and the Commonwealth of Virginia will review and approve final well locations.

3.3.7 Sampling of On- and Off-Site Clay Deposits

This task will provide samples of clay for laboratory determination of permeability for screening of potential clay deposits for cover material. Tests of clay will include proctor density, Atterberg limits, and laboratory permeability on compacted samples.

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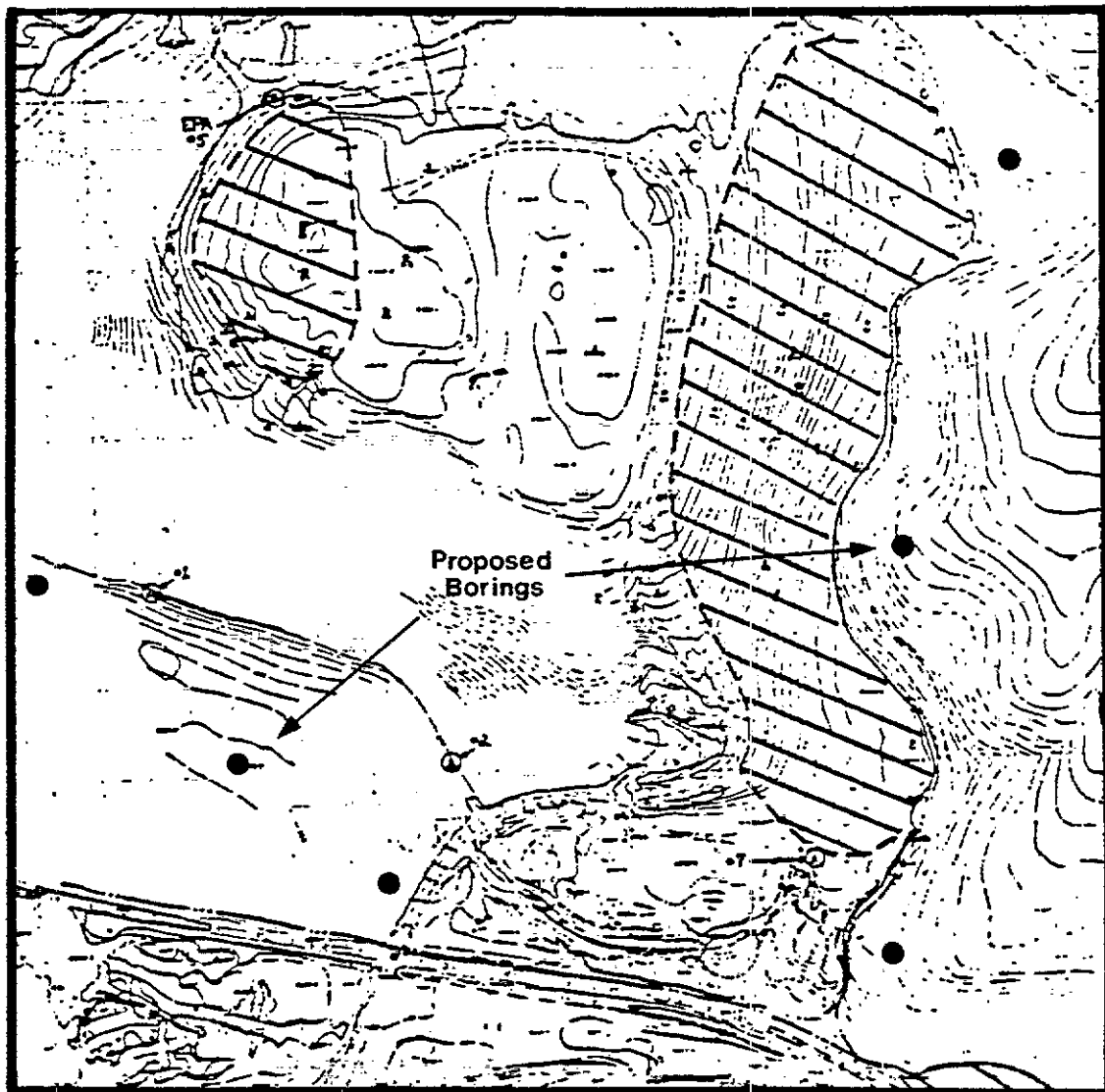


Figure 3.5. Approximate locations of shallow, hand-augered borings identified in Section 3.3.6(d).

3.3.8 Monitoring of pH, Specific Conductivity
and Total Dissolved Iron in Piney River

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The Piney River will be monitored bimonthly for a period of at least four months. For each sampling event, one sample of water will be obtained at each station for the laboratory analysis of total dissolved iron. At the time of sampling, field pH and specific conductivity of the river will also be measured at each station. The six river sampling stations are described as follows (see Figure 3.6).

STATION NO.

1. An upstream station will be established along the north bank of the Piney River under the Route 151 bridge. This upstream station is considered to provide samples representative of the average Piney River water quality before it passes the U.S. Titanium site.
2. A station will be established along the north bank of the Piney River just upstream of Area 5, but downstream of the plant area. This station is not considered to represent average Piney River water quality, but is considered only to represent local water quality near the north bank.
3. A station will be established in the middle of the channel of the Piney River just upstream of Area 5, but downstream of the plant area (when flow permits). This station is not considered to represent average Piney River water quality, but is considered only to represent local water quality at that point.

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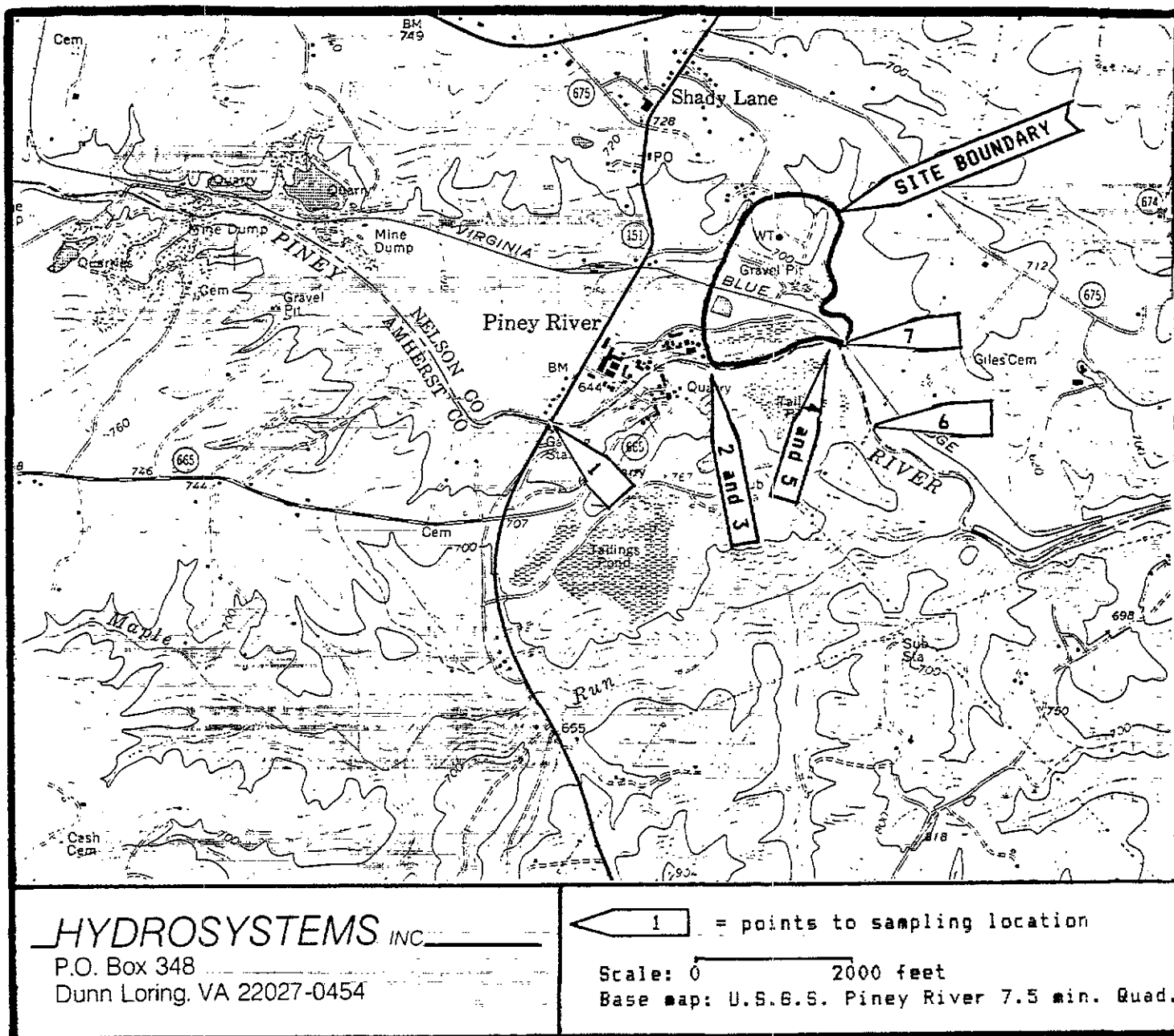


Figure 3.6. Map showing locations of sampling stations in Piney River near the U.S. Titanium site, Piney River, Virginia.

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4. A station will be established along the north bank of the Piney River just upstream of the culvert draining Area 7. This station is not considered to represent average Piney River water quality, but is considered only to represent local water quality near the north bank.
5. A station will be established in the middle of the channel of the Piney River just upstream of the culvert draining Area 7 (when flow permits). This station is not considered to represent average Piney River water quality, but is considered only to represent local water quality at that point.
6. A downstream station will be established along the north bank of the Piney River at the power-line crossing about 1,000 feet downstream of the culvert draining Area 7. This downstream station is considered to provide samples representative of the average Piney River water quality downstream of the U.S. Titanium site.

Since the time required to obtain a valid pH measurement at each river sampling station is considerable, it is impossible to complete the sampling of the river stations within a short time. Therefore, to determine the importance of diurnal variation on river pH, a one-day sampling program will be conducted. For this program, pH in the Piney River will be measured at stations 3 and 6 as identified in Tasks 3.3.8(a) and (b) approximately every two hours beginning at 6:00 am and ending at 8:00 pm.

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To augment the routine bimonthly sampling of the Piney River water quality, at least one sampling event will be conducted during low flow of the Piney River. Samples will be collected at each of the six stations identified in Task 3.3.8. In addition, best efforts will be made to conduct river sampling at stations 1, 5, and 6 during a storm runoff event (based on experience in measuring pH in the river during the Summer of 1986, the number of stations has been reduced to meet the two-hour sampling schedule). Also, sampling of the culvert discharge (Station 7, Figure 3.6) will be conducted during the storm runoff event. To the best of our ability to predict the occurrence of storms, this sampling would be conducted approximately every two hours and would begin at least two hours prior to commencement of precipitation and cease after runoff from the site begins to abate.

3.4 TASK 4 - SITE INVESTIGATION ANALYSIS

3.4.1 Hydrogeologic Conceptual Model

3.4.1.1 Assessment of Fracture Flow

To address concerns raised about the nature of groundwater flow through the saprolite and fractured bedrock, a review of literature will be conducted concerning the occurrence of groundwater in the Piedmont. Based on the findings of this literature research, an evaluation of the importance of fracture flow through the bedrock as a migration pathway will be made.

3.4.1.2 Characterization of Aquifer Permeability

Aquifer permeability will be assessed by conducting aquifer tests on the 13 existing wells installed previously, the nine temporary wells identified in Section 3.3.5(e), the six shallow hand-augered borings identified in Section 3.3.6(d), and three shallow hand-augered borings identified in Section 3.5.1. (See Appendix B for description of test method).

3.4.1.3 Water-Table Elevation Contour Map

Using the water-level data developed from the permanent monitoring wells, contour maps of the water-table elevation for each sampling date will be generated.

3.4.1.4 Groundwater flow direction map

Groundwater flow direction maps will be constructed for each water-table contour map generated pursuant to section 3.4.1.3.

3.4.1.5 Hydrologic Budget

A hydrologic budget for each area and for the site as a whole will be prepared. The hydrologic budgets will be prepared to show the average monthly water balance. The components of the water balance are:

$$\text{PERC} = \text{PRECIP} - \text{AET} - \text{RUNOFF} \pm \text{SMS} + \text{GWI} - \text{GWO} \quad (3.1)$$

where:

PERC = average monthly percolation to the water table,

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PRECIP = average monthly precipitation,

AET = average monthly actual evapotranspiration,

RUNOFF = average monthly runoff,

SMS = average monthly change in soil moisture storage,

GWI = average monthly groundwater inflow from upgradient, and

GWO = average monthly groundwater outflow downgradient,

PRECIP is taken from actual records of average monthly precipitation for nearby weather stations. The National Climatic Center publishes records for two nearby stations, Piney River 2 SE and Lynchburg Municipal Airport. The weather data for the Piney River 2 SE station is limited to incomplete records of daily precipitation and daily minimum/maximum temperature over the period 1976 to present. The Lynchburg station, located about 20 miles to the south, is operated by the National Weather Service and has very complete data. Monthly average precipitation and temperature are reported for the Lynchburg station for the period 1944-1977 in Ruffner (1980). It is proposed that the Lynchburg data be used.

The first water-balance component to be estimated is the monthly average potential evapotranspiration (PET). Monthly PET is estimated by the Thornthwaite method (Rosenberg et al, 1968):

$$PET = 1.6 (10T/I)^a \quad (3.2)$$

where:

PET = monthly potential evapotranspiration (in cm),

T = monthly mean temperature (in degrees centigrade),

I = $(T/5)^{1.514}$, called the monthly heat index, and

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$$a = 6.75 \times 10^{-7}t^3 - 7.71 \times 10^{-5}t^2 + 1.79 \times 10^{-2}t + 0.49.$$

The second component to be estimated is the soil moisture. For purposes of the water balance, it is assumed that the soil achieves the maximum moisture content by January and maintains it through the end of May. This period is the time of maximum rainfall and minimum evapotranspiration. The initial soil moisture in storage is estimated from published values of the maximum soil moisture content for various types of soils. For example, Thornthwaite and Mather (1957) report a field capacity (the maximum soil moisture content) of 37.5% for clay loam and 45% for clay (soil types typical of those found at the U.S. Titanium site). Moisture retained in the soil at the end of each month is calculated from tables of soil moisture retention provided by Thornthwaite and Mather (1957) and is based on the monthly PET.

According to Fenn et al (1975), RUNOFF for each month is estimated by multiplying the monthly PRECIP by runoff coefficients for various surface conditions given in Chow (1964). Fenn et al (1975) state that this method will underestimate surface runoff in most cases.

Infiltration (INF) is estimated by Fenn et al (1975) as PRECIP minus RUNOFF. Since RUNOFF will be underestimated, INF will be overestimated, giving a conservative estimate of leachate production or groundwater recharge.

For the estimation of AET, the potential water loss, INF minus PET, is calculated. For those months where $INF > PET$, the rate of evapotranspiration is not limited, and AET equals PET. When $INF < PET$,

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AET is less than PET and is limited by the available soil moisture. In this case,

$$AET = PET + [(INF - PET) \pm SMS] \quad (3.3)$$

PERC, therefore, is estimated as $INF - AET$.

For estimating percolation of water through a clay cover liner, infiltration through the vegetated soil cover overlying the clay liner is estimated using the method of Fenn et al. (1975) as discussed above. The water that infiltrates through the soil cover to the top of the clay liner either runs off the sloping clay liner or percolates through the clay liner into the landfill.

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The average monthly percolation through the soil cover is input into the calculation of percolation through the clay liner presented by Kmet et al. (1981).

The method of Kmet et al. (1981) calculates the average monthly percolation through the clay liner by accounting for the amount of time water resides on top of the clay liner, allowing percolation, versus the time it takes for the water to run off the sloping surface of the clay. The amount of infiltration estimated by the Fenn method that reaches the top of the clay is converted to a hydraulic head on the clay by dividing the average monthly percolation rate through the soil cover by the porosity of the soil.

The time for the water to drain off the surface of the clay liner and the time to leak through the liner are calculated using Darcy's law (and the effective porosity). The time that is shorter is used in the calculation of the amount of water that can percolate through the clay liner. If the time is longer than a month, than water left over at the end of the month must be incorporated into the calculation of the hydraulic head for the next month.

The flow through the clay liner is calculated essentially by Darcy's law, but corrected for the slope of the liner, i.e., the length of the flow path is longer than the thickness of the liner by the inverse cosine of the slope.

GWI, average monthly groundwater inflow from upgradient, is calculated by:

$$GWI = KiA_i \quad (3.4)$$

where:

K = aquifer hydraulic conductivity from aquifer tests,

i = upgradient hydraulic gradient measured from water table contour maps, and

A_i = cross-sectional area of inflow on the upgradient side of the subject area.

GW_O is calculated in a similar manner to GWI except the hydraulic gradient (i) and cross-sectional area of outflow (A_o) are measured on the downgradient side.

3.4.2 Geochemical Conceptual Model

3.4.2.1 Current Extent of Contamination

The extent of contamination in soils, surface water, and groundwater determined from the boring and monitoring program will be delineated on maps. For Area 1, the amount and form of copperas will be estimated.

3.4.2.2 Characteristics of the Source of Contamination in Each Area

For each area, the source of contamination will be described geochemically.

- a. Observed ranges of concentrations of total dissolved iron and levels of pH in the leachate, surface runoff, and groundwater outflow generated by each area will be tabulated.
- b. Chemical reactions that control the contaminant levels in leachate and the fate of contaminants in site runoff and groundwater and in the Piney River will be described. The controlling chemical reactions will be deduced from the reported concentrations of the major chemical constituents, the reported mineralogy of the soil and rock, and the observed mineral deposits forming in the channels and surface seeps. The natural groundwater geochemistry is controlled by the weathering of the granitoid metamorphic and igneous bedrock. Typical of the Piedmont (Davis and DeWiest, 1966, p. 331) the natural groundwater is low in total dissolved solids (TDS) and hardness, for example, 132 and 254 mg/l TDS and 80 and 84 mg/l hardness as CaCO_3 in two nearby wells (VPI, 1984).

In general, the dominant controls on leachate geochemistry are the solubility of copperas, the redox equilibria of Fe(II) and Fe(III), and the hydrolysis of Fe(III).

- c. Estimates of the total amounts of contaminants in each source and the average annual and monthly flux of contaminants emanating from each source will be made.

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The amount of contaminants in each source will be estimated from the data derived from the boring programs described in Section 3.3.

3.4.2.3 Contribution of Each Area to Surface-and Groundwater Contamination

The hydrologic budgets developed pursuant to section 3.4.1.5 will be used in conjunction with the observed concentrations in surface and groundwater to estimate the contribution of each area to the acidic discharges leaving the site via surface- and groundwater. The results of this analysis will provide monthly average flow rates of acidic leachate from each area. In addition, the percent of total acidic discharge to the Piney River contributed by each area and by groundwater will be estimated.

3.4.2.4 Variations in Contaminant Levels over Time

Based on the data developed from Task 3 as a result of surface- and groundwater monitoring and data collected in previous studies, the variation in contaminant levels in the surface- and groundwater will be evaluated. Relationships between flow rates and contaminant levels in the site runoff and Piney River will be assessed. Time scales over which variations in water quality will be analyzed include seasonal, diurnal, and storm-event scales.

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3.5 TASK 5 - LABORATORY AND BENCH-SCALE STUDIES

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3.5.1 Evaluation of On-Site Clay for Cover Material

The samples of clay obtained in the task described in Section 3.3.7 will be analyzed for suitability as cover material. Three field tests of permeability by slug test in auger holes will be conducted. Laboratory tests for Atterberg limits and permeability will be performed on three disturbed samples of the clay. These data will provide information to determine suitability of this clay as cover material, including evaluation of the permeability and shrink-swell capacity.

3.5.2 Contamination Potential of Areas 4 and 6

Data collected pursuant to Task 3, Section 3.3.4, and data and analyses developed by Dr. John Novak, VPI, concerning Areas 4 and 6 will be evaluated. In addition, X-ray diffraction analysis of samples collected from Areas 4 and 6 will be conducted to determine mineralogical composition of the material. Chemical analyses of pore water or leachate from Areas 4 and 6 will be conducted for total dissolved iron and pH to determine acid-producing capacity. If the material is found to be a source of acidity, the material will also be texturally characterized and permeability tests will be conducted to allow estimation of the impact of the areas on ground- and surface-water quality.

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3.5.3 Runoff From the Site Requiring Diversion

In order to estimate design criteria for any necessary site runoff diversions, estimates of the average daily and 25-year peak flow rates, maximum discharge velocities, 25-year storm event precipitation and duration, and quality of runoff will be made.

3.6 TASK 6 - REPORTS

Monthly progress letter reports will be submitted to EPA-III and the Commonwealth of Virginia during the conduct of the SRI. The data, analyses, and interpretations developed during the SRI will be presented in a report entitled "Supplemental Remedial Investigation of the U.S. Titanium Site, Piney River, Virginia."

3.7 TASK 7 - COMMUNITY RELATIONS SUPPORT

The requirement for community relations support will be handled by EPA-III (verbal communication with Carol Stokes, EPA-III, recently replaced by Michael Bass).

3.8 TASK 8 - DATA MANAGEMENT

Data management will be accomplished in a manner to facilitate data analyses, report preparation, and quality assurance procedures. All numerical data will be entered into a computerized data base maintained on a microcomputer. The data base management system will be a Lotus 1-2-3 brand software package. Lotus 1-2-3 provides ready application of statistics and graphics packages to the data.

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3.9 TASK 9 - QUALITY ASSURANCE

Quality assurance procedures described in the Quality Assurance Plan (see Appendix B) will be followed during the course of this Supplemental Remedial Investigation.

3.10 TASK 10 - SAMPLING PLAN

Procedures for the collection and analysis of samples and analysis of data are described in the Sampling Plan (see Appendix C). Those procedures will be followed during the course of this SRI.

3.11 HEALTH AND SAFETY

For purposes of the Supplemental Remedial Investigation, Level D personnel protection provides adequate worker health and safety. Since the SRI work will be performed solely in the designated site areas and at the up- and downstream river monitoring stations, the only potential contaminants that personnel may be exposed to are copperas waste and acidic leachate and runoff. These potential contaminants and their concentrations do not present any significant health or safety hazard.

Level D protection consists of a normal work uniform that includes cloth coveralls or pants, protective gloves when sampling leachate, and boots with steel toe and shank. For site personnel involved in power augering or well drilling, hard hats and eye and ear protection is required.

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Unrelated to the site contamination, but, nevertheless, important to health and safety is the ubiquitous presence of natural hazards such as poison ivy, wood ticks, mosquitoes, bees, and brambles. Site workers will be advised of these natural hazards and appropriate clothing and protective insect sprays suggested.

In the event that emergency services are required, site personnel can call the 911 emergency telephone number.

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4.0 SCHEDULE FOR SUPPLEMENTAL REMEDIAL INVESTIGATION

1. Submittal of Draft SRI Work Plan to EPA-III and Commonwealth of Virginia - 45 days from signing of the agreement.
2. Completion of Site Investigation work (except Piney River Monitoring) - 60 days from approval of work plan by EPA-III and Commonwealth of Virginia.
3. Completion of Piney River Monitoring - 120 days from approval of work plan by EPA-III and Commonwealth of Virginia.

In the event that storm event or low flow sampling are not accomplished during the 120-day period for completion of the river sampling program, the schedule for completion of the program may be extended for an additional period not to exceed 60 days.

4. Completion of Site Investigation Analysis and Laboratory and Bench Scale Studies (except for Piney River Monitoring) - 45 days from completion of site investigation work (no. 2).
5. Submittal of Draft Supplemental Remedial Investigation Report - 60 days from completion of site investigation analyses (no. 4).

In the event that the schedule for completion of the river sampling program is extended to provide additional time for the conduct of storm event or low flow sampling, the draft Supplemental Remedial Investigation Report may be revised to reflect any storm event or low flow data collected during the extension.

6. Submittal of Draft Feasibility Study Work Plan to EPA-III and Commonwealth of Virginia - 30 days from submittal of draft SRI report or revised draft SRI report (no. 5).

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5.0 STAFFING PLAN

The project team for the performance of the Supplemental Remedial Investigation is shown in Figure 5.1. The professional profiles for the team personnel are presented in Appendix A.

The Project Director for HYDROSYSTEMS, Inc. is Lyle R. Silka, P.G. (Professional Geologist). Mr. Silka has overall responsibility for project completion and coordination with American Cyanamid Company, the Commonwealth of Virginia, and the EPA concerning technical matters.

Dr. Janet S. Herman will be the Quality Assurance Director and will report directly to the Project Director.

The Project Manager, or site manager, is Jeffrey A. Sitler, P.G. He has responsibility for overseeing all field work and directing the daily activities of the SRI. The Project Manager will be supported by staff and associates of HYDROSYSTEMS, Inc.

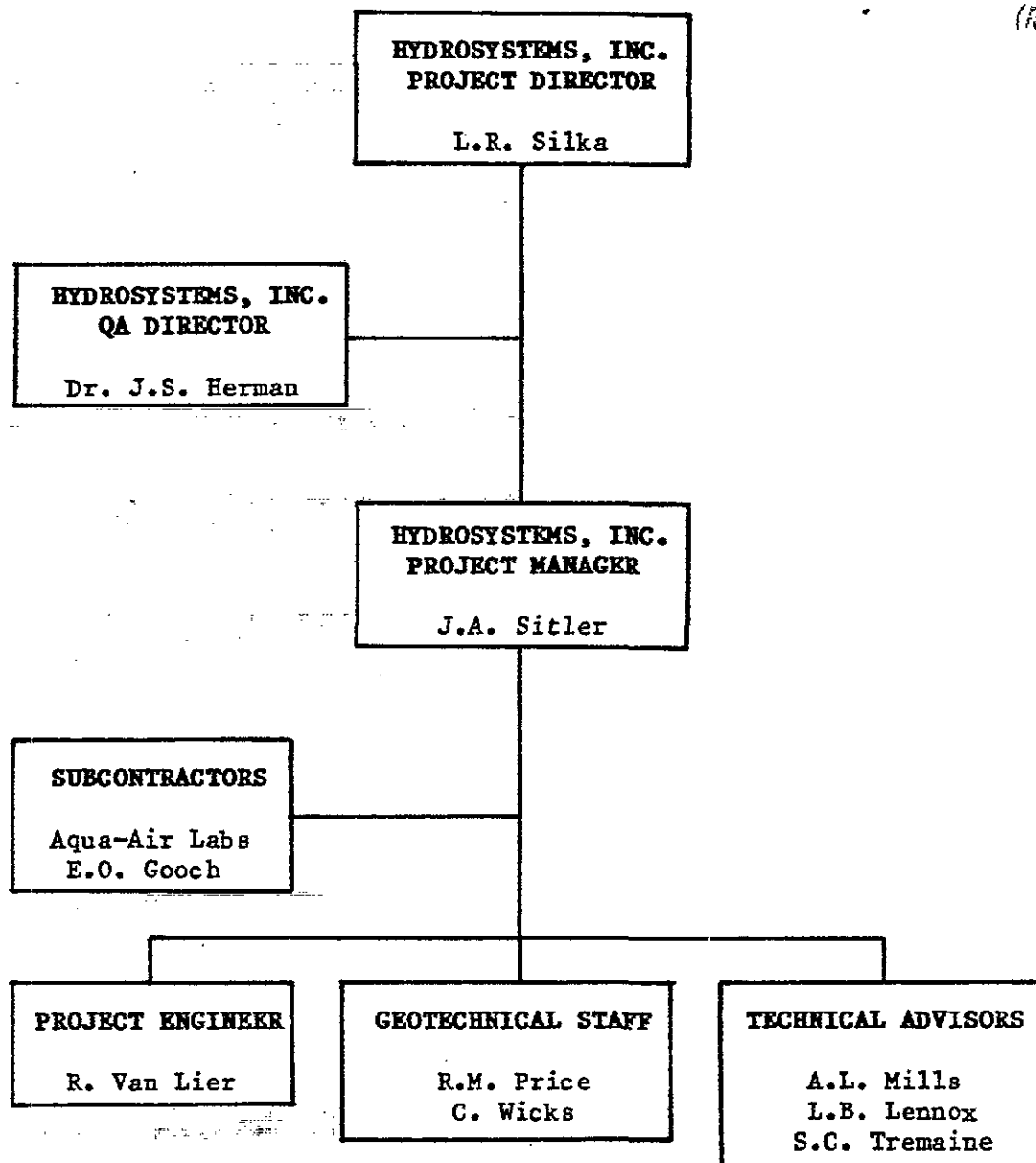
Robert Van Lier, P.E., will serve as the Project Engineer.

Technical advisors include Dr. Aaron L. Mills in soil science and microbial ecology; Dr. Linda B. Lennox in terrestrial ecology and forestry; and Ms. Sarah C. Tremaine in aquatic ecology.

Additional subcontractors will be required to support the Supplemental Remedial Investigation. The subcontractors required include analytical laboratory, well drilling, and engineering laboratory.

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Figure 5.1. Project organization chart for the Supplemental Remedial Investigation at the U.S. Titanium site.

6.0 SUBCONTRACTING PLAN

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HYDROSYSTEMS, Inc. is the prime contractor for the SRI.

Aqua-Air Laboratories, Inc. of Charlottesville, Virginia is the subcontractor for chemical analytical work. Aqua-Air Laboratories is a certified NPDES laboratory and conducts chemical analyses under contract with the Commonwealth of Virginia.

E.O. Gooch and Associates of Charlottesville, Virginia is the well drilling subcontractor (in unconsolidated sediments). E.O. Gooch conducted the borings for the burial pit for U.S. Titanium Corporation in 1979 and conducted additional borings in Area 1 for HYDROSYSTEMS, Inc. in the Spring of 1986.

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APPENDIX A

PROFESSIONAL PROFILES

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Section No. A
Revision No. 1
Date: 6/12/86
Page: 1

LYLE R. SILKA
President
Senior Hydrogeologist

B.S. - Geology
M.S. - Hydrogeology

Mr. Silka has over twelve years of experience in the field of hazardous waste management, both for the private sector and government. Mr. Silka has been involved in the study of groundwater contamination and evaluation of remedial actions at active and abandoned facilities and has provided guidance in the permitting of proposed facilities. In addition, he has provided technical support in negotiations with the EPA and states and has presented expert testimony.

Currently, Mr. Silka is the principal technical consultant to a petroleum company named a responsible party in a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) case in Tacoma, Washington. Mr. Silka has prepared technical reviews of the EPA remedial investigations and feasibility studies and participated in negotiations concerning the source of solvent contamination and appropriate remedial actions to be taken. In regards to the identification of the source of contamination of the municipal wellfield, Mr. Silka designed a soil-gas survey to be conducted in the vicinity to locate previously unknown sources of contamination. In addition, he developed a computer model of the groundwater flow system and conducted a groundwater tracer study to determine flow direction and velocity.

300858

In previous consulting work, Mr. Silka completed groundwater modeling of the French drain and clay cover installed at Love Canal, in Niagara Falls, New York. This study, conducted for EPA, focused on the effectiveness of those remedial actions in reducing leachate production and capturing contaminated groundwater.

From 1976 to 1980, Mr. Silka was a staff hydrogeologist with the U.S. Environmental Protection Agency in Washington, D.C. and Region VII in Kansas City. During his tenure with the EPA, he was the technical project manager for the \$5 million national assessment of groundwater contamination potential from waste disposal in surface impoundments. For that study, Mr. Silka designed the methodology for ranking sites and developed the guidance and training for the state personnel responsible for carrying out the data collection.

Also while with the EPA, Mr. Silka provided technical support during the development of regulations for underground injection control under the Safe Drinking Water Act (SDWA), hazardous and solid waste regulations under the Resource, Conservation and Recovery Act (RCRA), and implementation plans for CERCLA. During this time, he was technical consultant to the EPA Office of Waste Programs Enforcement, providing expert technical assistance in negotiations concerning the cleanup of several hazardous waste sites.

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Other examples of Mr. Silka's experience in the hazardous waste field are summarized below:

- o Applied computer modeling to the evaluation of remedial actions at hazardous waste sites and to the determination of potentially responsible parties.
- o Designed and conducted environmental risk assessments at hazardous waste sites.
- o Designed and implemented groundwater monitoring systems at sites for the detection of accidental releases of hazardous chemicals.
- o Prepared and presented expert testimony before federal court and state regulatory hearings concerning groundwater contamination.
- o Applied various field and analytical techniques to problem solving, including:
 - aquifer tests (pump tests),
 - aerial photographic interpretation,
 - groundwater and surface-water sampling,
 - field analysis of chemical parameters using ion-selective electrodes and wet chemistry field kits,
 - laboratory methods for chemical and hydrologic analyses,
 - computer modeling of groundwater flow and chemical transport
 - groundwater tracer studies, and
 - geophysical techniques including electrical resistivity and seismic methods.

Mr. Silka has published over 20 journal articles. He is a registered professional geologist in the States of Delaware and Indiana and is a member of the Association of Ground Water Scientists and Engineers, the National Water Well Association, the Geological Society of America, and the Association of Engineering Geologists.

300860

JEFFREY A. SITLER
Executive Vice President
Senior Hydrogeologist

B.S. - Geology
M.S. - Geology

Mr. Sitler has over seven years of experience supervising hydrogeologic studies of waste disposal facilities including site evaluations, monitoring network design, groundwater monitoring well installation, aquifer tests, and groundwater sampling.

During the past two years, Mr. Sitler has been involved in several studies of groundwater contamination from wastewater lagoons, industrial landfills, and acid mine drainage. Mr. Sitler also provided expert testimony in litigation concerning the contamination of a water-supply well with gasoline from a leaking underground storage tank.

As an employee of the University of Virginia, Mr. Sitler was manager of data-collection activities for a study of the impacts of acid rain on a watershed in the Blue Ridge province of Virginia.

Mr. Sitler has worked on acid-mine drainage problems in Pennsylvania for a number of years, evaluating acidic runoff from abandoned mines and implementing reclamation projects involving application of sewage sludge and revegetation. These acid-mine drainage problems are of a similar nature to the U.S. Titanium site in that the acid-mine drainage chemistry is essentially identical to the leachate chemistry at the U.S. Titanium site.

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Mr. Sitler has experience in field data collection including both supervision and conduct of:

- o test boring and well logging,
- o pump tests,
- o monitoring well design, installation, and sampling,
- o field measurement of chemical parameters using ion-selective electrodes and wet chemistry techniques,
- o aerial photographic interpretation, and
- o geophysical methods including
 surface electrical resistivity and
 seismic surveys.

Mr. Sitler is a registered professional geologist in the Commonwealth of Virginia and is a member of the Association of Ground Water Scientists and Engineers and the National Water Well Association.

300862

ROBERT J. VAN LIER, P.E.
Environmental Engineer

ORIGINAL
(Red)

B.S. - Civil Engineering
M.S. - Civil Engineering (Environmental)

Mr. Van Lier has been involved in environmental engineering for over six years and has expertise in the management, treatment, and disposal of municipal and industrial waste.

Mr. Van Lier has expertise in wastewater treatment plant design, operation, and maintenance, sludge handling and disposal, and facilities planning and environmental assessment. For a municipality, he was responsible for managing the commercial and industrial wastewater discharges to the wastewater treatment plant.

In the field of hazardous and solid waste management, Mr. Van Lier has prepared plans for industrial clients to achieve compliance with RCRA hazardous waste management requirements and prepared facility closure plans. For the Navy, he prepared designs and specifications for hazardous waste storage facilities and has participated in environmental audits of industrial facilities.

Mr. Van Lier is a registered professional engineer in the Commonwealth of Virginia and is a member of the National Society of Professional Engineers and the Water Pollution Control Federation.

JANET S. HERMAN, PHD
Associate Geochemist

B.S. - Geology
Ph.D. - Geochemistry

ORIGINAL
(hcd)

Dr. Herman is a member of the Environmental Sciences faculty at the University of Virginia in Charlottesville, VA. She has worked with the staff of HYDROSYSTEMS on many projects providing expertise in groundwater and leachate geochemistry and providing quality assurance review.

Dr. Herman has over eight years of experience in the application of geochemistry to the interactions of water and rock in groundwater systems. She has specialized expertise in the application of equilibrium speciation, reaction kinetics and reaction path analysis to the study of the geochemical mechanisms controlling the chemistry of groundwater.

With reference to the U.S. Titanium site, Dr. Herman has conducted geochemical studies of acidic runoff from iron sulfide deposits in Pennsylvania. These studies included the evaluation of the effectiveness of limestone for neutralization of the acidic runoff.

Past project involvement includes the following geochemical studies:

- o study of geochemistry of groundwater in limestone terrane in southern Spain and interpretation of karst formation (for the U.S. Geological Survey)
- o evaluation of lime neutralization as a remedial action for acid runoff (for the Department of Transportation)
- o analysis of geochemical controls of acidic leachate containing heavy metals (for an industrial client)

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- o study of the mobility of thorium in groundwater (for the Nuclear Regulatory Commission)
- o review of natural analogs for the study of geochemistry of radionuclides in groundwater at high-level radioactive waste repositories (for the Nuclear Regulatory Commission).

Dr. Herman is a member of the Geochemical Society, the American Geophysical Union, the Association of Ground Water Scientists and Engineers, and the National Water Well Association. She is a member of the editorial board for the Ground Water Journal.

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(100)

AARON L. MILLS, PHD
Associate Soil Scientist/Biologist

B.A. - Biology
M.S. - Soil Science
Ph.D. - Soil Science (Microbial Ecology)

Dr. Mills has experience in environmental pollution problems spanning a 15 year period. He is a member of the faculty of the Department of Environmental Sciences at the University of Virginia. Dr. Mills has applied his expertise to the study of the behavior and fate of organic and inorganic contaminants in soils; surface waters, including freshwater, estuarine, and marine environments; and groundwater. Results of his studies have provided assessments on the potential and actual rates of microbial degradation of organic pollutants in the environment, including analyses of the organic compounds and their metabolites.

In work closely related to the U.S. Titanium case, Dr. Mills has conducted extensive studies on the microbial amelioration of acid mine drainage. He evaluated the effects of acid mine drainage from abandoned pyrite mines in central Virginia on microbial communities in a downstream freshwater reservoir and assessed the role of sediment microbes in the mitigation of acidity. Dr. Mills developed preliminary methods to mitigate acid runoff through the use of bacteria.

In addition, Dr. Mills has acted as technical advisor and given expert testimony on behalf of the State of Maryland in coal mine permit hearings.

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Selected projects Dr. Mills has been involved in include:

- o Study of oil and metal pollution from industrial sites in Maryland on shellfish communities in Chesapeake Bay (U.S. Department of Commerce)
- o Study of the behavior of spilled crude oil from the supertanker METULA along the Chilean coast of the Straits of Magellan. (National Science Foundation)
- o Provided expert testimony in mine site hearings on behalf of the Maryland Division of Natural Resources.
- o Assessed the potential for groundwater contamination from the disposal of toxic organic chemicals in septic systems. (industrial client)

LINDA B. LENNOX

Associate Terrestrial/Microbial Ecologist

B.S. - Forestry

M.S. - Forest Soils

Ph.D. - Microbial Ecology

Dr. Lennox has over twelve years of experience in studying the effects of soil microbes on plant growth. Dr. Lennox has specialized in microbial processes in the root zone that enhance plant growth, such as mineralization, nitrogen fixation, and biological control of root diseases. Dr. Lennox directed studies and work relating to the establishment of vegetation on alkaline iron and copper mine tailings for the Michigan Department of Natural Resources.

Dr. Lennox maintains an appointment as research professor in the Environmental Sciences Department at the University of Virginia.

300867

SARAH C. TREMAINE
Associate Aquatic Ecologist

ORIGINAL
(Red)

B.S. - Biology
M.S. - Aquatic Ecology
Ph.D. Candidate in Aquatic Ecology

Ms. Tremaine has been involved in the field of aquatic ecology for over eight years. She has conducted field investigations and analyses of the effects of pollution from a variety of sources on aquatic life. These studies have been carried out in streams, freshwater lacustrine, brackish estuarine, and marine environments. In addition, her dissertation research at the University of Virginia has focused on the amelioration of acid mine drainage by sulfur-reducing bacteria.

Past projects include the following:

- o Study of the effects of watershed landuse on the biological processes in lakes and streams.
- o Study of the role of sulfur-cycle bacteria on the amelioration of acid mine drainage.
- o Investigation of the unintentional microbial degradation of lubricating oils used by a brass rolling mill. Implementation of recommended corrective measures to control microbes have proved 100% effective.
- o Assessment of the impacts of road construction on a salt marsh ecosystem. Recommended changes in local road construction materials to mitigate the adverse effects.
- o Evaluated the thermal tolerance of salt marsh fish species to power plant thermal effluent.

300868

CAROL M. WICKS
Staff Geochemist

ORIGINAL
(Red)

B.S. - Chemical Engineering
M.E. - Chemical Engineering
M.S. - Environmental Sciences (expected 1987)

Over the last six years, Ms. Wicks has been involved in several chemical engineering research projects related to production process design and process computer simulation, and the design of a radioactive waste volume reduction process. Currently Ms. Wicks is involved in research related to the transport and fate of trace metals in an acidic stream and lake system located in a pyrite mining district in central Virginia.

During past employment, Ms. Wicks developed a computer model of the Tyvek chemical process for the E.I. DuPont De Nemours and Company, in Richmond, Virginia. For Philip Morris Inc. of Richmond, Virginia, she was responsible for process development and pilot plant studies on primary tobacco processing.

Ms. Wicks is a member of the American Geophysical Union, the Environmental Section of the American Institute of Chemical Engineers, the Association of Ground Water Scientists and Engineers, and the National Water Well Association

300869

RENE M. PRICE
Staff Geochemist

ORIGINAL
(Red)

B.S. - Geology

M.S. - Environmental Sciences (expected 1987)

Over the past two years Ms. Price has been actively involved in the environmental evaluation of several waste disposal sites, including one CERCLA site. She has taken part in many phases of the field investigations including: surface- and groundwater sampling, field analysis of collected waters, supervision of monitoring well installation, and conduct of permeability tests in bore holes.

Currently, she is studying the groundwater geochemistry of a limestone aquifer in Spain under a grant from the U.S. Geological Survey.

Ms. Price is a member of the American Geophysical Union, Geochemical Society, the Association of Ground Water Scientists and Engineers, and the National Water Well Association.

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APPENDIX B

QUALITY ASSURANCE PLAN
SUPPLEMENTAL REMEDIAL INVESTIGATION
U.S. TITANIUM SITE, PINEY RIVER, VIRGINIA

VERSION 2.0

SEPTEMBER 12, 1986

APPROVAL SIGNATURES

Project Manager: _____ Date: _____
Jeffrey A. Sitler

Project Director: _____ Date: _____
Lyle R. Silka

QA Manager: _____ Date: _____
Janet S. Herman

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QUALITY ASSURANCE PLAN DISTRIBUTION LIST

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Jerome Muys, Esq., Breed, Abbott & Morgan
Mike Bass, U.S. Environmental Protection Agency, Region III
Tedd Jett, Virginia State Water Control Board
John Butcher, Esq., Commonwealth of Virginia, Attorney General's Office
Lyle Silka, HYDROSYSTEMS, Inc.
Jeffrey Sitler, HYDROSYSTEMS, Inc.
Janet Herman, HYDROSYSTEMS, Inc.
John Pierce, Jr., AQUA-AIR Laboratories

1.0 PROJECT DESCRIPTION

The purpose of the Supplemental Remedial Investigation is to augment the existing data base relating to the nature and extent of the acidic discharges at the U.S. Titanium site in Piney River, Virginia. The investigation includes water-quality measurements of the Piney River, groundwater, and site runoff. The sources of contamination will be delineated utilizing a soil boring program in areas of known and suspected contamination. Contaminant migration in groundwater will be described utilizing measured water levels and contaminant concentrations obtained from existing and temporary wells.

In order to better understand and quantify the impact acidic discharges are having on the Piney River, a water-quality monitoring program for the Piney River has been designed. This program includes the field measurement of pH and specific conductance at six sampling stations located in the river. Of the six stations, one is upstream of the site, four are adjacent to the site, and the sixth is 1000 feet down stream (see Appendix C, Sampling Plan for exact locations). Water samples also will be collected at each river sampling station for laboratory measurement of total dissolved iron.

Water samples collected from on-site monitoring wells and surface drainage from the site will be analyzed for pH and specific conductivity in the field; and total dissolved iron, and sulfate in the laboratory.

Additionally, a soil boring program will be utilized to collect solid waste and soil samples from the site. Samples collected from the

copperas burial pit will be analyzed for copperas content. Soils collected from Areas 1, 2, and 3 will be analyzed for pH and nutrient content (nitrogen, phosphorus and potassium) by the Virginia Cooperative Extension Service lab at Blacksburg. Solid waste samples will be collected from Areas 4 and 6 to determine their acid-producing potential.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITY

Project Director: Lyle R. Silka

ORIGINAL
(red)

Address: 2042 Peach Orchard Drive, Suite G-30
Falls Church, VA 22043
(phone 703-573-1690)

Responsibility: Reviews field work progress. Analyzes field data for completeness and accuracy. Recommends additions and/or revisions to site work. Completes monthly progress reports. Provides coordination with American Cyanamid Company, Commonwealth of Virginia, and EPA.

Project Manager: Jeffrey A. Sittler

Address: 303 Minor Ridge Road
Charlottesville, VA 22901
(phone 804-973-9740)

Responsibility: Organizes and oversees field work at site. Reports to Project Director.

QA Manager: Janet S. Herman

Address: 303 Minor Ridge Road
Charlottesville, VA 22901
(phone 804-973-9740)

Responsibility: Reviews data for completeness and accuracy. Routinely evaluates measurement procedures for accuracy. Ensures maintenance of a complete QA file of all collected data and other project records such as tracking forms and laboratory analysis results.

3.0 DATA QUALITY OBJECTIVES

3.1 Surface- and Groundwater

Samples of Piney River water, on-site surface waters, and groundwater will be analyzed as a basis for determining the extent of contamination. The samples will be analyzed in the field for pH and specific conductivity and in the laboratory for total dissolved iron and sulfate. The data quality objectives related to the laboratory analysis of sulfate and total dissolved iron and the field measurement of pH and conductivity are outlined in Table B.1.

3.1.1 Piney River

The water-quality data for the Piney River will be used to delineate the extent of contamination of the Piney River due to discharges from the U.S. Titanium Site, and the variability of the contamination related to weather extremes. The overall data quality objective is to produce data which will accurately represent the conditions existing in the Piney River as related to each sampling location.

The water-quality parameter of most concern is pH since it is the only mandatory State water-quality standard violated in the past. In addition specific conductivity and total dissolved iron will be determined. This parameter list was derived at through discussions with EPA and State personnel, and American Cyanamid and their representatives during a meeting in Washington, D.C. in the spring of 1986.

Specific conductivity and pH will be measured in the field. Total dissolved iron will be measured in the laboratory on a filtered and

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acidified sample. Previous studies have indicated that pH values will range between 4.0 and 7.0, with the bulk of the measurements in the range of pH 6.0 to 7.0. Variations between up-stream and down-stream locations will range between 0.2 and 2.0 pH units.

Specific conductivity measurements are expected to range between 15 and 75 umhos/cm in the Piney River. Total dissolved iron in the river is expected to range between 0.03 and 0.60 mg/l.

Water-quality data will be collected from six locations in the Piney River, twice a month over a period of at least 4 months, beginning in May of 1986. This time schedule was at the request of Tedd Jett, with the State Water Control Board (SWCBB). This period of time should be sufficient to cover both wet and dry climatic conditions.

The first station is up-stream of the site, four are within the site boundary, and one is down-stream of the site. These locations will be sufficient to determine contaminant input from the site. The selection of these sites was derived at through discussions with EPA and State personnel at the spring 1986 meeting.

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TABLE B.1

SUMMARY OF PRECISION, ACCURACY AND COMPLETENESS OBJECTIVES

Parameter	pH	Total Dissolved Iron
(Method)	(electrometric)	(atomic absorption, EPA Method 236.1)
Method Reference	EPA 600/4-79-020	EPA 600/4-79-020
Experimental Conditions (see Note 1)	44 Analysts in 20 Laboratories 1 Synthetic Water Sample pH = 7.1	79 Laboratories Analyzed 1 Synthetic Water Sample 0.438 mg/l Fe
Precision (as one Std. Dev.)	+/-0.20 units	+/-0.183 mg/l
Accuracy (as Bias)	1.01%	-0.29%
Completeness	90%	90%
Detection Limits	NA (see Note 2)	0.01 mg/l
Holding Time	In Field	6 months (see Note 3)

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TABLE B.1 (continued)

SUMMARY OF PRECISION, ACCURACY AND COMPLETENESS OBJECTIVES

Parameter (Method)	Sulfate (EPA Method 375.4, Turbidimetric)	Specific Conductance (AC bridge)
Method Reference	EPA 600/4-79-020	EPA 600/4-79-020
Experimental Conditions (see Note 1)	34 Analysts in 16 Laboratories Analyzed 1 Synthetic Water Sample 199 mg/l Sulfate	41 Analysts in 17 Laboratories 1 Synthetic Water Sample 100 umhos/cm
Precision (as one Std. Dev.)	+/-11.8 mg/l	+/-7.55 umhos/cm
Accuracy (as Bias)	-1.7%	2.02%
Completeness	90%	90%
Detection Limit	2 mg/l	NA (see Note 2)
Holding Time	7 days (see Note 2)	In Field

Notes

1. Experimental conditions selected based on similarity of synthetic water to actual field conditions anticipated.
2. Detection limit not applicable since parameter range is limited.
3. Holding times from Scalf et al. (1981, EPA-600/2-81-160).

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3.1.2 Other Surface Waters and Groundwater

The water-quality data obtained for other surface waters and groundwater at the site will be used to characterize the extent of on-site contamination. The data quality objectives are presented in Table B.1.

In addition to field pH and conductivity, and laboratory dissolved iron, sulfate will be determined in the laboratory. The range expected for each parameter is as follows: pH, 2.5 in site drainage to 7.0 in the river; specific conductivity, 400 umhos/cm in the river to 14000 umhos/cm in site drainage; dissolved iron, 0.01 mg/l in the river to 2600 mg/l in site drainage; and sulfates, 200 mg/l in the river to 18000 mg/l in site drainage.

3.2 Soil and Solid Waste Samples

3.2.1 Soils for Nutrient Analysis

Samples of surficial soils will be collected from areas 1, 2 and 3 for routine analysis of nitrogen, phosphorus, potassium, pH, and soluble salts by the Virginia Cooperative Extension Service in Blacksburg. These analyses are to be solely used for the determination of revegetation requirements of denuded areas. A more rigorous analysis is not required for this purpose. The analytical methods used can be found in "Reference Soil Test Methods for the Southern United States", Southern Cooperative Services Bulletin 190.

3.2.2 Copperas Content Determinations

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To provide input into the estimation of the amount of copperas remaining in the burial pit, numerous samples of soil/copperas will be collected from borings and analyzed for copperas content. Since the material to be analyzed is composed of a variable mixture of clay and copperas, a simple analysis for the copperas content can be used. The analytical method relies on the fact that copperas is infinitely soluble while the clay is virtually insoluble and background levels of copperas are zero.

Solution and agitation of a known weight of waste in deionized water will dissolve the copperas, leaving the clay residual. Repeated dissolution, centrifuging, and decanting will ensure virtually complete removal of the copperas. The determination of when complete removal of copperas is achieved is made by repeated specific conductivity measurements on the decanted liquid. The dissolution of the sample is complete when two successive conductivity measurements are less than 500 umhos/cm (essentially background) and the percent change in conductivity between the two is less than 10% (a change of <50 umhos/cm at 500 umhos/cm).

The difference in weight between the original sample and the clay residual is the weight of copperas contained in the sample. Extrapolation of these data from the borings to the whole burial pit will provide an approximation of the overall copperas content remaining in Area 1.

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Accuracy for this method is dependent on the total amount of soluble salts in the sample, the percent change allowed between conductivity readings when the test is completed, and to a lesser degree on accuracy of the conductivity meter (see Table B.1) and the balance. With the lower range in conductivity of about one thousand umhos/cm for a sample with about 1% copperas, the 10% change criteria (or <50 umhos/cm at 500 umhos/cm) represents greater than 95% accuracy. Including the accuracy of the conductivity meter, the accuracy is greater than 95%. As the percent copperas in the sample increases, the accuracy increases.

There is no limit on holding time for the copperas/soil samples. No standardized method is known to exist for this analysis.

3.2.3 Waste Samples

Samples from Areas 4 and 6 will be analyzed for their acid producing potential. The samples will be mixed with deionized water and the pH of the solution measured over time. This method should simulate actual field conditions thus allowing for the prediction of the acid producing potential of the wastes. There is no limit on holding time. No standardized method is known to exist for this analysis.

4.0 SAMPLING PROCEDURES

The sampling procedures, site locations, preservation methods and sample labeling are described in detail in the Sampling Plan, Appendix C of the Work Plan.

5.0 SAMPLE CUSTODY

In order to allow for the accurate tracking of all samples the following record keeping will be utilized. (Red)

5.1 Sample Labeling

A detailed description of the sample labeling procedures are contained in Section 3.2 of the Sampling Plan. Figure B.1 is an example of the sample labels which will be used.

Each label is waterproof and is to be completed at the time of sampling using waterproof ink. The information contained on the label will then be transferred to the field tracking form.

5.2 Chain-of-Custody Form

A chain-of-custody form will be prepared for each sample and will accompany its respective sample from time of collection, through delivery to the laboratory and analysis. As few persons as possible will handle the samples. Each transfer of custody of the sample will be recorded on the chain-of-custody form. Figure B.2 is an example of the chain-of-custody form.

5.3 Field tracking Form

As the samples are being collected the information contained on the labels will be transferred to the field tracking form (see Figure B.3). The tracking form will be numbered consecutively and maintained in a notebook by the QA Manager.

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(Red)

HYDROSYSTEMS, INC.
P.O. BOX 348 DUNN LORING, VA 22027

Project: _____
Date: _____ Time: _____
Sample ID Number: _____
Lab ID Number: _____
Sampling Location: _____
Sampled by: _____
Preservative: _____
Analysis and Comments: _____

Figure B.1. Preprinted sample label.

Client: _____				
Client Address: _____				ORIGINAL (red)
Contact Person: _____ phone: _____				
Sampled by: _____			Date: _____	
Client sample identification	Location/Test Parameters	Sampling date/time	# of samples/volume	preservative
released by: _____ date/time: _____		received by: _____ date/time: _____		
released by: _____ date/time: _____		received by: _____ date/time: _____		
received in laboratory by: _____ date/time: _____		method of shipment: _____		
comments: _____				

Figure B.2. Sample chain-of-custody form.

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5.4 Lab Tracking Form

At the laboratory, a log book consisting of serially numbered lab tracking forms will be maintained. When the samples are delivered to the lab, the tracking form is to be completed by the laboratory person responsible for the samples. In this case, John S. Pierce, Jr., with AQUA-AIR Laboratories in Charlottesville, Virginia, will be receiving the samples. Figure B.4 is a copy of the lab tracking form which will be used.

5.5 Field Measurement Record Keeping

In addition to the previously described records, a serially numbered record book will be kept of all measurements made in the field. This bound book will contain instrument calibration and measurement data for field pH, temperature, specific conductance, and water-level data obtained on-site during this program. It will also include the information found on the field tracking form. After each sampling event, a copy will be made of the appropriate pages and forwarded to the QA manager for evaluation and filing.

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Site Location: U.S. TITANIUM SITE, PINEY RIVER, VIRGINIA
Contractor: AQUA AIR LABORATORIES, INC., Charlottesville, VA

[illegible]

Figure B.4. Lab tracking form.

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6.0 CALIBRATION AND ANALYTICAL PROCEDURES

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Routine calibration of all instrumentation used for the measurement of specific water-quality parameters is required. For the Supplemental Remedial Investigation of the U.S. Titanium site, instrumentation will be utilized in the analysis of total dissolved iron (atomic adsorption), pH (electronic meter with pH electrode), specific conductance (specific conductance meter), and sulfates (spectrophotometer).

Each calibration will be documented by the recording of the date, standards used, raw data used for calibration curves and the person performing the calibration on the laboratory analyses form for laboratory analyses and in the field notebook for field analyses.

6.1 Field Measurements

Field measurements of pH and specific conductance will be performed by the staff of HYDROSYSTEMS, INC.

6.1.1 pH Meter Calibration and pH Measurement

Before each pH measurement, the meter will be calibrated using a two-buffer calibration method. Based on previous studies, the pH of Piney River water will range from 4.0 to 7.0, while the pH of on-site surface water and groundwater will range from 2.5 to 7.0. Therefore, the calibration of the pH meter will utilize buffer solutions of pH 4.0 and 7.0 for samples with a pH above 4.0 and buffer solutions of pH 2.0 and 7.0 for samples with a pH below 4.0. The buffers utilized are color coded and have known temperature compensation values provided by the

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manufacturer. The buffers are obtained from Fisher Scientific and (Red)
guaranteed to be within 0.01 pH unit at 25 °C.

The buffer containers are rinsed with fresh buffer solution and refilled with fresh buffer solution prior to each day of sampling.

The procedure for pH measurement is as follows:

- A. The buffer containers are immersed in the water to be measured for at least ten minutes for temperature equilibration. During this time the water temperature is measured using a thermometer which has previously been checked for accuracy in an ice bath.
- B. The pH electrode is then rinsed with deionized water and immersed in the 7.0-pH buffer. Using the calibration knob the meter reading is adjusted to the pH of the 7.0 buffer based on the known temperature compensation values supplied by the buffer manufacturer. For example, at a temperature of 15 °C, the 7.0 buffer actually has a pH of 7.05 (Fisher Scientific).
- C. The electrode is then rinsed with deionized water and placed in either: 1) the 4.0 buffer for samples that will have a pH above 4.0, or 2) the 2.0 buffer for samples that will have a pH below 4.0. The slope or temperature knob is then adjusted until the required reading is observed.
- D. As a check of the instrument operation and calibration, the electrode is then rinsed with deionized water and the steps B

and C above are repeated. If the reading is off by more than 0.02 units the calibration is repeated.

E. The electrode is rinsed with the water to be measured and immersed in a sample bottle containing a fresh sample of the water. The sample bottle is kept partially immersed in a larger volume of sample water or the surface water body being measured to maintain a constant sample temperature.

F. The pH reading is completed when the meter reading stabilizes. For low ionic strength waters such as is found in the Piney River, a single pH reading will take 45 minutes at a minimum, depending on the water temperature, and the condition of the electrode. The time required for stabilization (response time) and pH are then recorded. During this project, a Corning combination electrode, which is recommended for low ionic strength solutions, will be used.

G. The electrode is then rinsed with deionized water and the calibration rechecked following steps B through D.

6.1.2 Specific Conductivity Meter Calibration

Before each day in the field, the conductivity meter calibration will be checked using a standard potassium chloride conductance solution (VWR Scientific, catalog no. AL51340-4, or equivalent, 0.01 M KCl). If the instrument does not read the correct value for that KCl solution at 25°C (1413 $\mu\text{mhos/cm}$), a new cell constant will be calculated using Method 205 described in Standard Methods (pp.71-75). The method is as follows:

- A. Thoroughly rinse the electrode with a 0.01 M KCl solution. The solution is prepared by dissolving 745.6 mg of anhydrous KCl in enough deionized water to make a 1 liter solution.
- B. Place electrode in a beaker of fresh 0.01 M KCl solution at 25 degrees C and measure conductivity.
- C. A 0.01 M KCl solution at 25 °C will have a calculated specific conductance of 1413 $\mu\text{mhos/cm}$. Therefore the cell constant is equal to 1413 divided by the observed value.

The measurement procedure for specific conductivity is as follows:

- A. The conductivity cell is placed in the water to be measured. In the case of surface waters, the cell is placed directly in the water body. In the case of well waters, the cell is first rinsed with the well water then immersed in a sample container of the water. The cell is allowed to equilibrate for several minutes.
- B. The meter is then calibrated using the internal standard. This is accomplished on this instrument (YSI Model 33) by adjusting the red line control knob so that the meter needle deflects to the red line on the scale when the meter is in the adjustment mode. This procedure allows for the determination of the operating condition of the instrument. A reading is taken. The reading is multiplied by the cell constant and recorded.

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6.1.3 Corrective Actions

In the event that the above calibration procedures cannot be accomplished satisfactorily the following corrective actions will be taken.

- A. The batteries will be replaced with fresh batteries and the calibration procedures will be repeated.
- B. In the case of the pH meter, if changing the batteries does not solve the problem, the back-up electrode will then be used and the calibration procedures will be repeated.
- C. If neither procedure corrects the problems, the instruments are not field repairable.

6.2 Laboratory Calibration and Measurement Procedures

Water analyses for total dissolved iron and sulfate will be performed by AQUA-AIR Laboratories located in Charlottesville, VA. This lab was chosen because of its proximity to the site and its adequate qualifications for chemical analyses of water under the State NPDES laboratory program.

6.2.1 Total Dissolved Iron Calibration and Measurement

Total dissolved iron is measured by atomic absorption (AA) using EPA Method 236.1. At the beginning of each day the AA unit is adjusted according to the manufacturer's specifications. The AA unit is then calibrated using a blank and a 5 mg/l Fe standard. The calibration is then checked by analyzing one or more EPA quality assurance samples

having known iron concentrations. Blanks are run between each sample, and an analysis of the standard is repeated after every 10 to 20 sample analyses.

6.2.3 Sulfate Analysis

Sulfate analysis will be performed in accordance with turbidimetric method (EPA Method 375.4). The spectrophotometer (Spectronix Model 20) is calibrated using a standard curve determined using a blank sample and three prepared standards covering the range in sample concentration values expected (i.e., 200 to 18,000 mg/l). This procedure is repeated for each test series.

6.2.4 Copperas Content Determination

Due to the expected high concentration of soluble salts (i.e., copperas) in the samples of soil/copperas mixture from Area 1, the standard method for the analysis of soluble salts in soils used by the Virginia Cooperative Extension Service is not applicable. Natural soils in the Piney River area contain very small amounts of total soluble salts, generally causing specific conductivity readings of several hundred umhos/cm or less. (The standard method employed involves measuring the conductivity of a solution composed of one part soil to two parts distilled water.)

However, with the samples of copperas waste, it is expected that the soluble salts will comprise from about one percent to a majority of the sample weight. Therefore, in most cases, the use of the standard method would result either in specific conductivity values that exceed the

capabilities of the instrumentation or incomplete dissolution of the copperas. To further discourage the use of the standard method, adding additional amounts of water is not recommended, because the resulting conductivity measurements tend to exaggerate the soluble salt content in soils when there is excessive amounts of sulfate as would occur with the copperas (Greweling and Feech, 1965). Thus, a modification of the standard method for measuring total soluble salts has been designed to handle the special circumstances of the copperas waste.

6.2.4.1 Method Summary

The method for determination of copperas involves the repeated leaching of the soils to dissolve and remove the copperas contained in that sample. The conductivity of the leachate is monitored and will decrease with successive leaching to a level expected in natural soils, indicating that the copperas has been removed from the sample. The soil samples are dried and weighed both before and after the dissolution process and a weight percent copperas content is calculated from the weight loss.

6.2.4.2 Detailed Methodology

- A. Soil samples are air dried and pulverized to pass through a 1/4-inch mesh sieve.
- B. Using a 14-chute riffle splitter, the soil sample will be reduced in size to approximately 100 grams.

- C. The soil will be oven dried at 105 °C for 24 hours. The sample will be cooled and weighed to within 0.1 gms.
- D. The soil will be placed in a tared 250 ml centrifuge container. The centrifuge container containing the soil is then weighed to within 0.1 gms.
- E. Deionized water is added to the soil in the centrifuge container to bring the total volume in the centrifuge container to approximately 200 ml, and the solution is then stirred for 10 minutes to dissolve the copperas.
- F. The mixture is centrifuged until the soil is completely separated from the top of the water column. This water is decanted off, and its conductivity measured.
- G. Steps E and F are repeated until the conductivity of the decanted water decreases to less than 500 umhos/cm and the change in conductivity from the previous decanting is less than 10.0% (less than 50 umhos/cm at 500 umhos/cm).
- H. The final soil slurry is spread on a tared drying pan, and, along with the centrifuge container, will be oven dried at 105 °C for 24 hours, allowed to cool, and weighed to within 0.1 gms.
- I. After drying, the total weight of the remaining soil is calculated and is used to calculate the percent by weight of soluble copperas by Equation (1).

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$$\text{Weight Percent Copperas} = ((S_i - S_f)/S_i) * 100 \quad (1)$$

where:

$$S_i = C_{si} - C_i \quad (2)$$

$$S_f = D_f - D_i + C_f - C_i \quad (3)$$

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and

C_i is centrifuge container weight,
 C_{si} is centrifuge container and soil weight,
 S_i is initial soil weight,
 C_f is final centrifuge container weight,
 D_i is drying pan weight,
 D_f is final drying pan and soil weight, and
 S_f is final soil weight.

6.2.4.3 Quality Control

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As a means for maintaining the quality of the data produced by the copperas determination procedure, duplicate analyses will be performed. At least two sample splits will be analyzed to ensure accuracy. If a difference of more than 10% as weight of copperas occurs, two additional sample splits will be run. The value of the mean of the four samples will be used as the value for that sample. In addition, three standard mixtures of soil/copperas will be produced and analyzed using this procedure. The standards will consist of a known weight of dried soil mixed with a known weight of dry FeSO_4 powder to arrive at standards of 10%, 50%, and 90% copperas by weight. The percent recovery will represent the leaching efficiency of this procedure. Since ferrous sulfate (copperas) is a soluble salt, the analysis of the copperas content of the standards will be representative of the field samples.

6.2.5 Acid Producing Potential of Wastes

Samples of the material collected from Areas 4 and 6 will be analyzed for their acid producing potential. The method is modified slightly from VPI (1984, p. 7), Morris (1984, p. 17), and American Society of Agronomy (1965) in that agitation is continuous and pH measurements are repeated over longer time interval to ensure complete oxidation.

Approximately 20 grams of wet material will be mixed with 20 ml of deionized water and the solution agitated continuously for 2 hours. The pH of the solution will be measured at 30 minute intervals over the 2

hour period. This is to allow for the oxidation of ferrous iron, assuming it is present. As a control, the same procedure will be performed on a sample of clean quartz sand.

A measured pH less than 4.0 in the sample leachate at the end of two hours will be considered an indication that the material may produce an acidic discharge if in contact with infiltration or groundwater. This criterion has been selected because contaminated soils on site have pH's in the range of 2.0 to 4.0, while background soils have pH's above 5.1 (GCA, 1985, p. 3-9). Concern at the site presently have pH values below 4.0.

6.2.6 X-Ray Analysis of Wastes

As a means for identifying the mineralogic composition of the materials in Areas 4 and 6, X-ray diffraction analysis will be utilized. The procedure will be performed by Dr. R. Mitchell, mineralogist/petrologist, The University of Virginia. Observed diffraction patterns will be compared to standard published patterns for identification. Relative abundances of each component will be estimated based on relative x-ray diffraction response.

6.3 Permeability Tests

Field permeability tests will be conducted using a pumping or bailer test on both open bore holes and cased wells. The tests consists of pumping or bailing out the water in the bore hole to lower the water level.

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The pumping test is used when the permeability of the aquifer is great enough that a bailer cannot lower the water level sufficiently before recovery to obtain water-level readings. Considering the relatively low permeability of the earth material at the U.S. Titanium site, it is anticipated that the bailer test method will be applicable to all areas.

In the case of the pumping test, pumping flow rate and water level versus time are measured. For the bailer test, water level versus time is measured.

6.3.1 Bailer Permeability Test

6.3.1.1 Bailer Permeability Test Procedure

The bailer permeability test may be conducted on an open bore hole or cased well where the screen openings are of sufficient area not to interfere with the test. In any case, the hole is bailed as rapidly as possible to draw down the water level. When a sufficient drawdown has been achieved, at least one to two feet, the initial water level measurement is taken at time zero (0.0). Water-level measurements on the rising water level in the bore hole are made over time at intervals between water-level rises of from one to two inches, if possible. At

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least three and, if possible, five measurement intervals should be obtained to provide checks on accuracy of field measurements.

6.3.1.2 Bailer Permeability Test Analysis

The bailer test results may be analyzed by several methods.

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Figures B.5 and B.6 show the method of Zangar (1953) for partially penetrating open holes. The application of Zangar's method assumes:

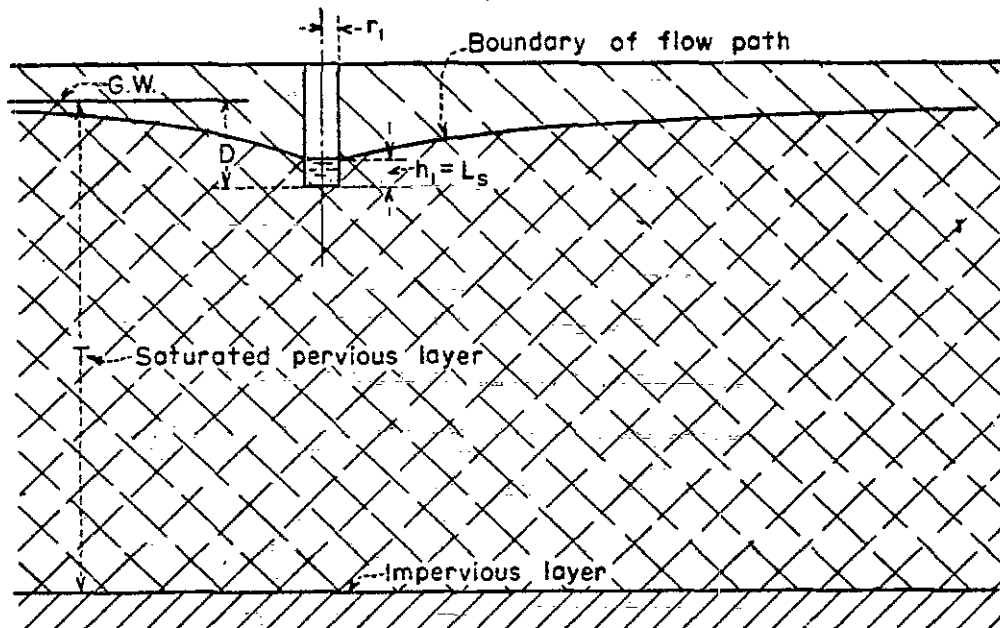
1. The bore hole is completed below the water table,
2. The aquifer is a homogeneous, isotropic, porous medium,
3. The extraction of water due to bailing is instantaneous,
4. The depth of penetration of the bore hole into the saturated zone is less than 20% of the total saturated thickness,
5. The aquifer is underlain by an impermeable boundary, and
6. The inflow into the well is constant over a measurement interval.

The average hydraulic conductivity (K) of the tested interval, interval D in Figure B.5, is calculated for each measurement interval. For example, the inflow during the first measurement interval, Q_1 , is calculated as follows:

$$Q_1 = h_1 r_1^2 \pi / t_1 \quad (4)$$

where the parameters are as defined in Figure B.5, and t_1 is the time interval for the first measurement interval. The value of Q_1 is input into Figure B.5 to calculate a value of K for the first measurement interval. The value of K for subsequent intervals is determined in the same manner.

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FORMULA:
$$K = \frac{1}{C_s r_1} \frac{Q}{H}$$

DEFINITIONS: Q = Well discharge - positive into well (ft.³/sec.)
 C_s = From figure 4I - use $\frac{h_1}{r_1} = \frac{L_s}{r_1}$
 $H = \frac{D^2 - h_1^2}{2D}$ (ft.)
Other values as shown

NUMERICAL EXAMPLE:

Let $T = 100$ ft., $D = 20$ ft., $h_1 = 10$ ft., $r_1 = 0.25$ ft., $Q = 0.10$ ft.³/sec.

Then $\frac{h_1}{r_1} = 40$, $C_s = 63$ (From figure 5'), $H = 7.5$

$$K = \frac{1}{(63)(0.25)} \frac{0.10}{7.5} = 0.00085 \text{ ft./sec.}$$

Figure B.5. Illustration of the analysis of a bailer test using the method of Zangar (1953).

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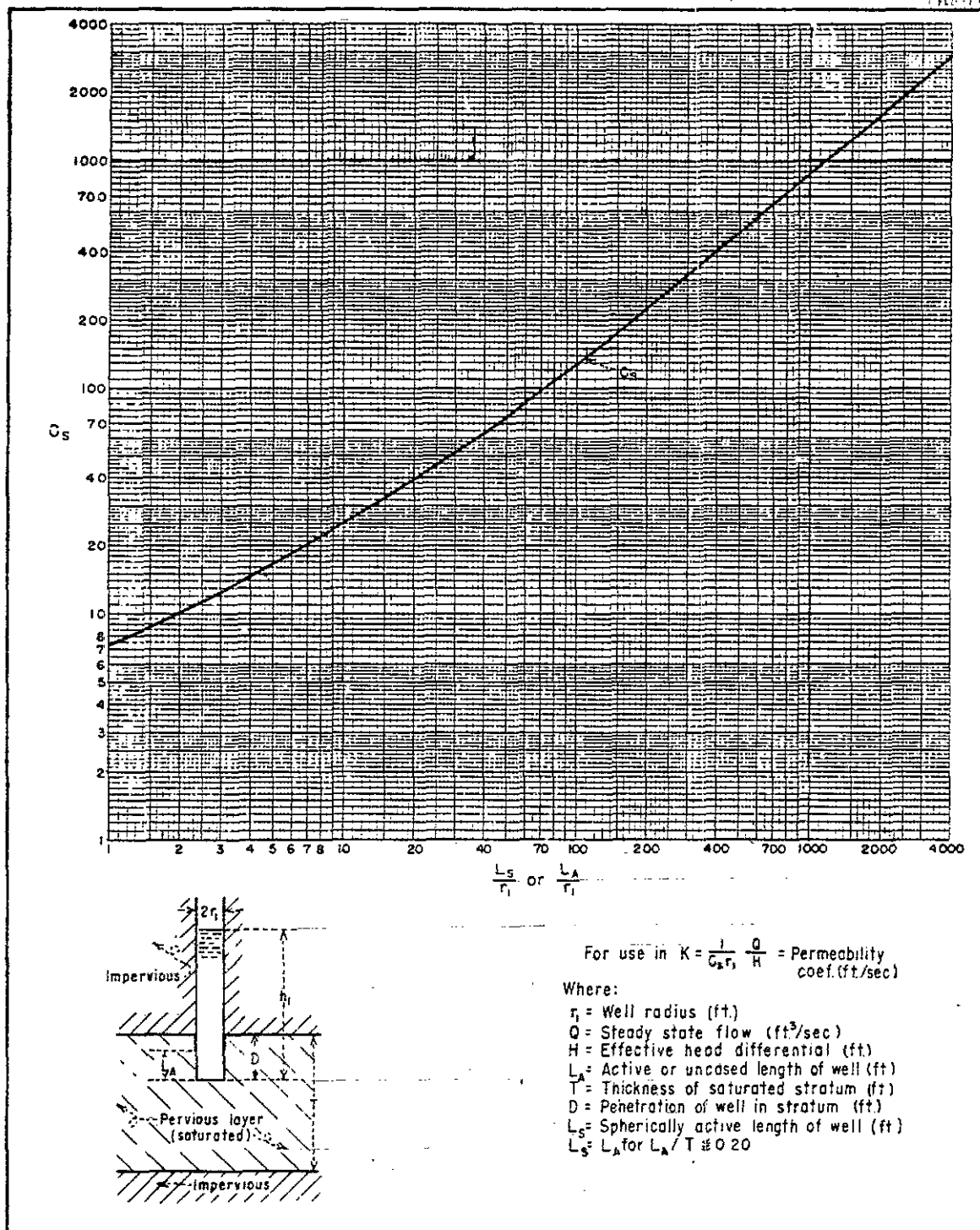


Figure B.6. Nomograph for determining the value of C in Figure B.5 for the method of Zangar (1953).

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Since the inflow into the bore hole will decrease over time due to (Red) declining head, the measurement interval must be kept relatively short so that the calculated value of Q from Equation (4) does not vary much from the real, instantaneous values of Q that occur at the beginning and ending of each measurement interval. This is the reason for basing the measurement interval on the incremental rise in water level in the hole.

Another method of analysis is based on the assumption that the bailer test can be approximated as a constant head test (in addition to the above assumptions). This assumption is approached when the incremental rise in water level over a measurement interval is kept small in relation to the total head, i.e., h_1 is much less than $D-h_1$ in Figure 4. The restriction of the incremental rise in water level to one or two inches over a given measurement interval will produce reasonably valid results when the length $D-h_1$ in Figure 4 is greater than one foot. The error introduced in the calculated value of K is less than 15% (Mercer et al. (1981, p. 4-24).

Under the constant-head analysis, K is calculated as follows (based on the slug-test method described in Mercer et al., 1981, p. 4-24 to 4-26):

$$K = \frac{2.3}{4(D)(\pi)(h_1)(\Delta 1/Q)/(\Delta \log t)} \quad (5)$$

where:

D is saturated depth of hole defined in Figure 4,

π is 3.1416,

h_1 is the water-level rise over the measurement interval,

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Q is obtained from Equation (4) above, and

$(\Delta 1/Q)/(\Delta \log t)$ is the slope of the straight-line portion of a plot of $1/Q$ versus the logarithm to base 10 of time (t).

(Note that the slug-test method is identical to the bailer-test method, but is an injection test).

A final method of analyzing the bailer test is based on the slug-test method of Ferris et al. (1962). The formula is:

$$T = Q_1 / 2(\pi)h_1(t_1) \quad (6)$$

where T is transmissivity, and all other parameters are as previously defined. The hydraulic conductivity, K, is calculated as:

$$K = T/D \quad (7)$$

6.3.2 Pumping Permeability Test

The pumping permeability test method utilized is as described in Stallman (1983).

6.3.3 Infiltration Tests

To determine infiltration rates in the sediments in Area 5, a ring infiltration test will be performed. The ring infiltrometer will be driven 6 inches into the sediment, a one inch layer of sand will be added and then the infiltrometer will be filled with water. The drop in water level will be measured as a function of time. The rate achieved after approximately ten minutes will be used to represent the infiltration for all precipitation events. As was shown by Foster

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(1948), the infiltration rate of soils decreases rapidly at the beginning of a precipitation event, leveling out at a lower constant rate for the remainder of the event. The majority of the infiltration occurs at this slower rate.

6.3.4 Laboratory Permeability Test

Laboratory permeability tests will be conducted by Hurt & Proffit Inc. of Lynchburg on clay samples that are representative of the deposits of clay that may be used as cover material. At least three samples from each clay deposit will be tested according to ASTM procedures for Atterberg limits (ASTM D-4318), proctor density (ASTM D-698) and standard permeability (Designation E-13 for nonloaded soils, USDI, 1980, p. 503, or equivalent). The tests will be conducted on reformed clay samples that achieve 90% of proctor density at optimum moisture content.

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7.0 DATA REDUCTION, VALIDATION AND REPORTING

7.1 Data Validation

During the course of the project, the data gathered will be subject to validation procedures to insure data integrity. Blanks and split samples will be analyzed in addition to the samples collected during each sampling event. As long as the blanks have values at or below the detection limit, the data will be assumed to be valid. Also the data will be reviewed as to its reasonableness as it relates to the known conditions existing at the site. For example, a pH in the Piney River above 7 would be questioned. The known river chemistry and the related geologic environment would not lead to a river pH above 7.

In addition, split sample analyses will be compared. Differences exceeding 10% would be questioned and the samples would be reanalyzed.

Mean, maximum, and minimum values for pH, specific conductivity and dissolved iron values will be reported for each station along the Piney River.

7.1.1 pH Analyses

Field pH measurements are being taken for each sample. In all cases, calibration and measurement procedures will be followed. The pH meter calibration will be checked both before and after each reading to ensure that instrument drift is minimized.

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7.1.2 Specific Conductivity

In general, conductivity measurements are reliable when calibration procedures are followed. A comparison of the relative changes between sampling points will be made. It is expected that within the Piney River, conductivity values will increase from up to down stream.

7.1.3 Total Dissolved Iron

The procedures for total dissolved iron in EPA 600/4-79-020 will be followed. Evaluation of the analyses of the split samples and blanks will be used to validate the dissolved iron data. Split samples should have a variability of 10% or less. Blanks should have dissolved iron concentrations at or below the detection limit. Comparison of adjacent sampling station values and previously obtained values will be utilized to identify outliers.

7.1.4 Sulfate

The procedures for sulfate analysis in water in EPA 600/4-79-020 will be followed. Split samples will be used to validate data.

7.2 Data Reporting

During the course of the project, the collected data will follow a specific reporting path. Both raw and validated data will be permanently filed with the QA Manager and in both HYDROSYSTEMS, INC. offices. The data will be entered into a computer system. Printouts of the raw data will be compared to the original data in field book and on the laboratory reporting forms to insure accurate transcription.

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The data collected in the field and reported by the laboratory will first be reviewed by the Project Manager. The Project Manager will also forward a copy of the raw data directly to the QA Manager for filing. After the Project Manager has reviewed the data, the data and a written report discussing the validity of the data is to be forwarded to the Project Director. The Project Director will review, amend and forward the report to the QA Manager. The QA Manager will recommend corrective measures if needed. The validated data will be recorded and filed by the QA Manager.

8.0 QUALITY CONTROL CHECKS

Quality control checks will be a routine part of site investigation. Approximately 10% of all samples analyzed will be for quality control. Split and blank samples will be submitted to the laboratory for analysis along with the collected samples. This procedure will be followed for both water and soil samples.

8.1. Blanks

During each sampling event, one blank will be prepared for delivery to the lab along with the regular samples. The blank will be prepared by adding deionized water to an acidified bottle, and will be labeled as sampling station 0. In addition, laboratory procedures described above routinely call for the use of blanks.

If the analysis of a blank reveals contamination, the blank would be reanalyzed to insure measurement accuracy. If the second analysis also shows contamination, the source will be identified. A sample of the preservative and of deionized water would be submitted for analysis. Once the source is identified, the affected data can be evaluated. If the preservative was contaminated, the concentrations measured in each sample would be reduced by the concentration measured in the blank sample.

Also during the routine calibration and measurement procedures, laboratory prepared blanks are utilized. When the measurement of a blank exceeds the instrument detection limit, the cause is investigated by the laboratory personnel and corrected.

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8.2 Split Samples

During each sampling event, two samples will be collected from one of the sampling stations and delivered to the lab as different samples. This split will include both the acidified sample and the unacidified sample. The results of the split-sample analysis will provide a check on the errors introduced by the combined effects of handling, storage, and laboratory factors.

If the split samples do not compare within 10% of each other, each will be reanalyzed. If the second analysis is different, the laboratory data for that sampling event would be in question. The remainder of the samples would be reanalyzed.

8.3 Replicate Samples

Replicate samples will be prepared in the lab from EPA QA standards for each parameter to determine laboratory accuracy and precision. Ten replicate samples of a single standard solution will be analyzed. This procedure will be conducted once during this investigation.

In addition, for each measured parameter, the same procedure will be followed for at least two samples collected in the field. These measured values will be analyzed for precision.

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8.4 Matrix Spikes

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On at least one occasion, a matrix spike sample will be prepared and analyzed. This procedure will be utilized to examine the measurement procedures for dissolved iron, sulfates and copperas content. The matrix spike will be prepared by adding a measured volume of a standard solution to a measured volume of an actual sample. The actual concentration is then calculated and the matrix sample is analyzed. The concentration of the matrix sample should be approximately three times the measured value for the sample. The measured value will be an assessment of the degree to which the instrument, sample handling procedures and chemical interferences affect the actual measurement.

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9.0 PERFORMANCE AND SYSTEM AUDITS

During the course of the investigation, unannounced audits will be conducted on both the field and laboratory phases of the investigation.

9.1 Field Procedures

During the course of the project, audits of the field procedures will be conducted by the Project Manager. The audit will include an evaluation of the measurement procedures for each parameter and the sampling protocol. This audit will be performed twice during the course of the Supplemental Remedial Investigation.

An audit report will be prepared which details any deficiencies.

9.2 Laboratory Procedures

AQUA-AIR LABORATORIES, INC. (AAL) is an EPA tested NPDES laboratory. The EPA yearly checks the performance of AAL in the NPDES (DMR QA) Laboratory Performance Evaluation Study. In addition, the Commonwealth of Virginia checks AAL for compliance with the Safe Drinking Water Act on an annual basis. AAL also regularly uses EPA Quality Assurance samples for in-house QA monitoring. As part of the calibration procedure before each set of analyses, AAL analyzes at least one EPA quality assurance sample.

In addition, the Project Manager will visit the laboratory at least once to review the laboratory records and sample handling procedures.

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9.3 Audit Reporting

Each audit will be recorded by the Project Manager and forwarded to the Project Director. The audit reports will include evaluations of record keeping procedures and completeness of records, and an evaluation of the analytical procedures.

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10.0 PREVENTIVE MAINTENANCE

Maintenance of equipment is scheduled in accordance with the manufacturers' recommendations, and a complete inventory of commonly needed repair or replacement parts is kept in stock. This applies to field equipment as well as lab equipment. Included in this list are:

pH electrodes,

batteries for portable equipment, and

tubing, gaskets and other parts for the atomic absorption unit.

11.0 PROCEDURES USED TO ASSESS DATA PRECISION AND ACCURACY

In order to assess the quality of the data being produced and the measurement systems, approximately 10% of all samples run in the laboratory will be quality assurance samples such as standards, replicates and splits.

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11.1 Accuracy

Accuracy is calculated as:

$$A = 100*(X-T)/T \quad (8)$$

where: A is accuracy,

X is measured value of known standard, and

T is true value of known standard.

EPA quality assurance samples are run once a year by AAL and in-house prepared standards are run daily as part of standard operating procedures.

11.2 Precision

Standard deviation is used as a measure of precision. In equation form:

$$S = ((\sum (X - \bar{X})^2) / (N - 1))^{0.5} \quad (9)$$

where: S is standard deviation,

X is a particular measurement,

\bar{X} is arithmetic mean of measurement on replicates or split samples, and

N is number of measurements.

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12.0 CORRECTIVE ACTION

Corrective actions will be initiated when data variability between replicates exceeds 10% or when instrument drift as determined by calibration after analyses exceeds 10%.

If corrective action is warranted, the previous sample or group of samples analyzed just before the QA check and after the calibration will be reanalyzed.

Since all data collected are direct measurements and not the result of data reduction calculations, the decision to take corrective action based on calibration checks rests with the lab manager and field technician.

In addition, corrective actions may be initiated by the QA Manager as the result of performance audits.

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13.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

Quality assurance reports will be prepared once a month by the Project Director and reviewed and filed by the QA Manager. The reports will include analysis of all QA data including data accuracy and precision. QA problems will be addressed and recommendations made in the QA report.

The Reports will also address the status of the project as it relates to the proposed time table.

In addition, the audits conducted will be summarized. Corrective actions taken as a result of these audits or assessments of data quality will be reported.

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14.0 REFERENCES

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APPENDIX C

SAMPLING PLAN

SUPPLEMENTAL REMEDIAL INVESTIGATION

U.S. TITANIUM SITE, PINEY RIVER, VIRGINIA

VERSION 2.0

By

HYDROSYSTEMS, INC.

P.O. Box 348

Dunn Loring, VA 22027

September 12, 1986

300929

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1.0 SAMPLING PLAN OBJECTIVE

This sampling plan describes sampling procedures required for the Supplemental Remedial Investigation (SRI) of the acidic discharges at the U.S. Titanium site, Piney River, Virginia. The sampling plan outlines procedures for the collection of water, soil, and solid waste samples at the site in accordance with guidance provided by the U.S. Environmental Protection Agency.

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2.0 SITE LOCATION AND ACCESSIBILITY

The U.S. Titanium site is located in the town of Piney River and is adjacent to and north of the Piney River. In general, physical access to all areas of the site is not a problem. The terrain is composed of rolling hills and flat valley-bottom land.

Approximately one-half of the site is contained within the flood plain of the Piney River, therefore, flooding events may temporarily restrict access to this area of the site, such as occurred during the November 1985 flood. High-river flow may also necessitate the temporary relocation of river sampling locations, i.e., move certain sampling locations to higher ground. In addition, sampling locations in the middle of the Piney River will be inaccessible during high flow events.

The clay-rich soils also may pose a problem for site access by vehicle. During and for some time after rainfall events, the site soils will not support two-wheel drive vehicles. Equipment such as drill rigs will also encounter problems during wet periods and should be kept off the site until the soils dry sufficiently. However, access to all sampling stations can be gained on foot from Route 151, near the plant site.

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3.0 WATER SAMPLING

Water samples are to be collected from both surface- and groundwater sources at the site. Twice a month, a sample from each of the six stations along the Piney River will be delivered to the laboratory for analysis of total dissolved iron. Field pH and specific conductivity will be measured at each sampling location at the time of sample collection. At least one of the sampling events will be timed to coincide with a period of low flow in the Piney River.

In addition, the flow from the culvert at the southeastern corner of the site will be sampled and measured on the same schedule as is the river sampling. Sulfate analysis will also be performed on the culvert discharge.

As a means for investigating diurnal variations in river chemistry, the Piney River will be monitored at two locations, once every two hours, over a 14 hour period. The 14-hour period will begin just at sunrise and end fourteen hours later. The parameters measured will be pH and conductivity. Sampling stations 3 and 6 will be used for this purpose. The diurnal sampling will be performed once during the course of the SRI.

To investigate the effects storm events have on the Piney River Chemistry, at least one storm event will be sampled. This program will include both sampling and field chemistry measurements on a two hour schedule, beginning before the rain event begins, and ending after runoff from the site begins to abate. Sampling stations 1, 5, 6 and 7 will be used for this purpose.

Samples collected from the permanent on-site wells will be laboratory analyzed for total dissolved iron and sulfates, and field analyzed for pH and specific conductivity. Water levels will also be measured before sampling each well. The wells will be sampled at least twice during the course of the SRI to investigate both wet and dry weather periods.

In addition, groundwater samples will be collected from temporary wells and borings emplaced during the site investigation. These samples will be analyzed for pH, specific conductivity, total dissolved iron, and sulfate.

3.1 Sampling Container Selection and Preparation

At each sampling station two samples are to be collected, one for the analysis of total dissolved iron and one for the analysis of sulfate and specific conductivity. The sample bottles are composed of polyethylene and have a volume of 250 ml. Since trace metal analysis is not being performed, acid washing of new the bottles is not necessary. However, if new bottles are not used, acid washing of the sample bottles will be performed.

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3.1.1 Bottles for Total Dissolved Iron Analysis

The day before each sampling event, the sample bottles used for collection of water for dissolved iron analysis are rinsed five times with deionized water. After rinsing, 2 ml of concentrated nitric acid is added to each bottle as a preservative for iron. This volume of acid will acidify the water samples to a pH of less than 2, thus preventing iron precipitation (EPA, 1976). Preprinted labels are attached to each bottle and labeled as being acidified (see Section 3.2.1 for labeling information). The bottles are then stored in an up-right position for use the next day.

3.1.2 Bottles for Sulfate Analysis

The bottles used for the collection of water samples for the analysis of sulfate require no special preparation. However, each bottle is to be rinsed three times with the water to be sampled, before collection of the sample.

3.2 Sample Container Labeling

Each water sample collected is to be labeled with a unique sample ID number and other pertinent data.

3.2.1 Preprinted Labels

Each sample container will have an attached, waterproof, preprinted label with the appropriate information completed using waterproof ink. The labels to be used are similar to that shown in Figure C.1. Each label is filled out at the time of sample collection. Included in Figure 1 is a key to properly filling out the label.

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Project: _____
Date: _____ Time: _____
Sample ID Number: _____
Lab ID Number: _____
Sampling Location: _____
Sampled by: _____
Preservative: _____
Analysis and Comments: _____

KEY TO FILLING OUT LABEL

Project: The project name and/or number given this project, i.e.
U.S. Titanium, Piney River River

Date: The date the sample is collected.

Time: The time of sample collection using 24 hour time.

Sample ID Number: The code which represents the sample (see
Section 3.2.2).

Lab Id Number: The number assigned by the laboratory.

Sampling Location: Description of sampling site, e.g. Piney River
under Route 151 bridge.

Sampled by: Person doing the sampling.

Preservative: Preservative used, e.g. Nitric Acid

Analysis and Comments: Required analysis and pertinent remarks,
e.g., filtered.

Figure C.1. Sample container label.

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3.2.2 Selection of Sample ID Codes

Each sample collected is to receive a unique sample ID number. The sample ID number is to consist of a sampling location code, a consecutive number, and a preservative code. Each code is described below.

3.2.2.1 Sample Location Codes for the U.S. Titanium Site

Code	Description
1	Piney River, north bank beneath Route 151 bridge, up-stream of site
2	Piney River, north bank just up-stream of Area 5
3	Piney River, center of channel just up-stream of Area 5
4	Piney River, north bank just up-stream of culvert at eastern edge of the site.
5	Piney River, center of channel just up-stream of culvert at eastern edge of the site.
6	Piney River, north bank 1000 ft down stream of site at power line crossing.
7	Discharge from culvert to Piney River at eastern edge of site (see Figure C.2 for River sampling locations).
W	Well codes are well numbers prefixed by a "W" EPA wells 1 to 5 = WEPA1, WEPA2, ... WEPA5 Other wells 1 to 8 = W1, W2, ... W8
TB	Temporary borings, i.e., TB1, TB2,...TB6

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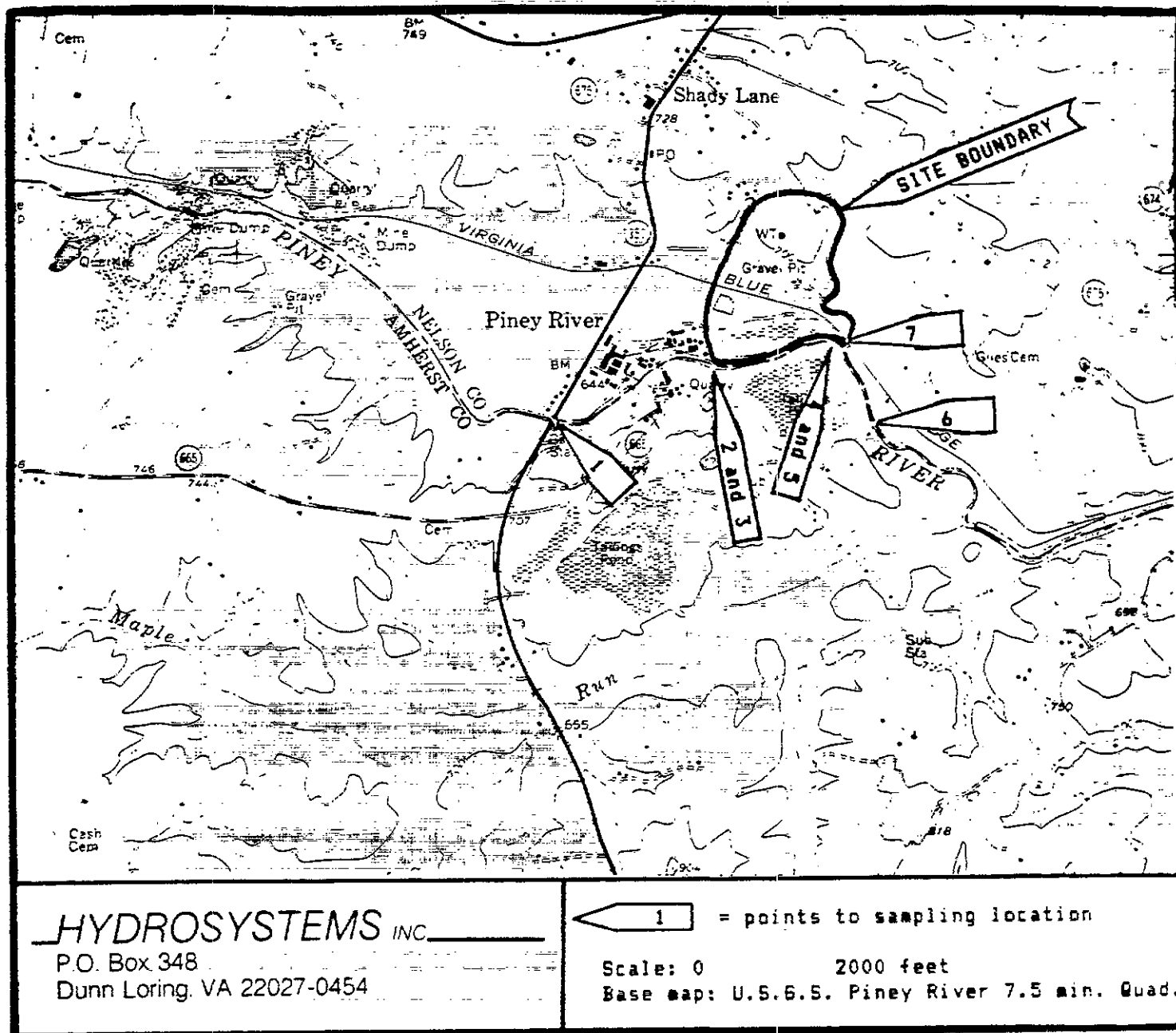
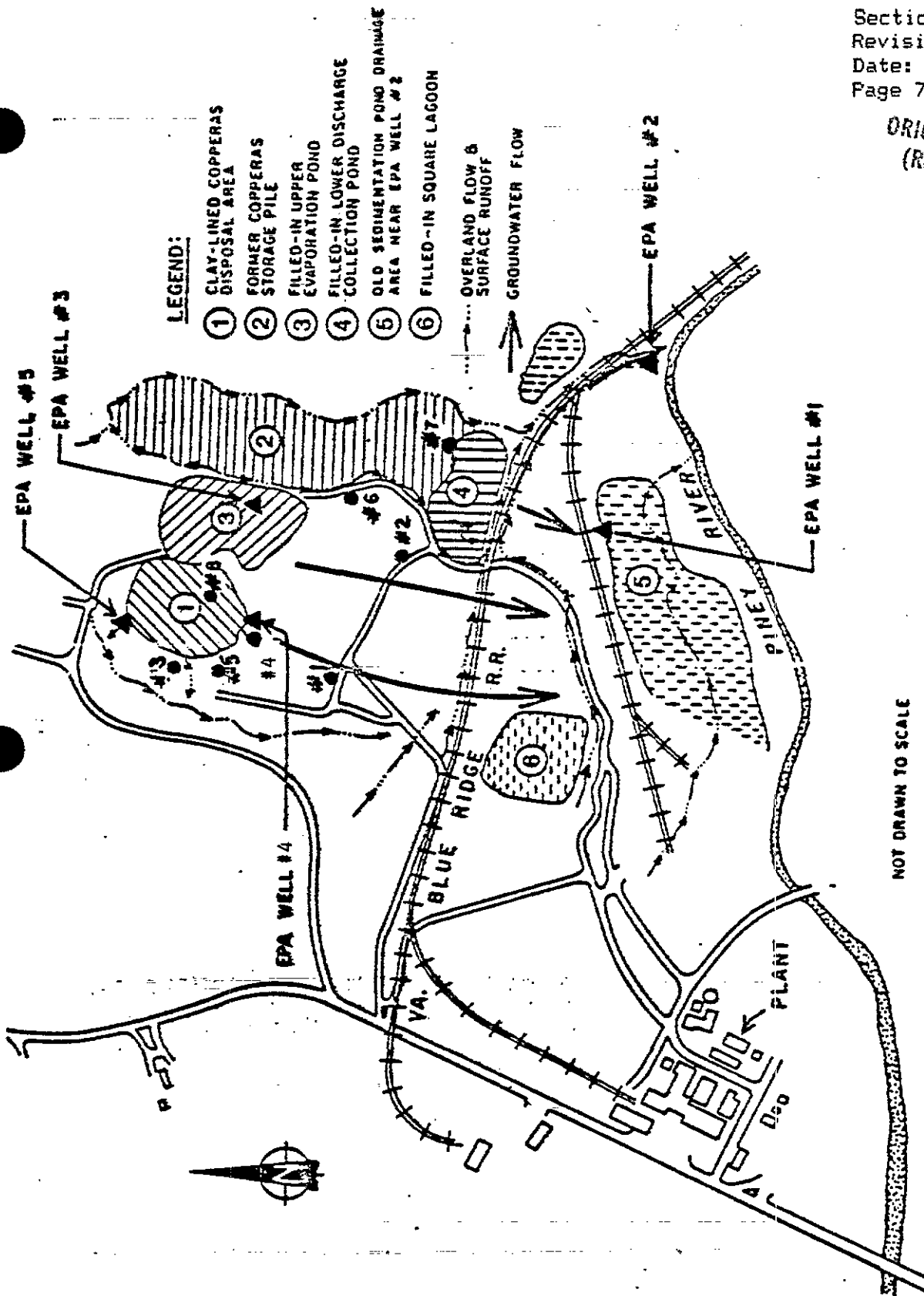


Figure C.2. Map showing locations of sampling stations in Piney River near the U.S. Titanium site, Piney River, Virginia.

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Well locations designated by ● and ▲ at the U.S. Titanium site.

Figure C.3. Map showing locations of well sampling stations at the U.S. Titanium site, Piney River, Virginia.

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3.2.2.2 Consecutive Numbers

Each sample will receive a consecutive number with the first sample being collected on the project numbered 001.

3.2.2.3 Preservative Code

Each sample is to receive a code which indicates type of preservative used.

Code	Preservative
A	Nitric Acid Alone
B	Refrigeration Alone

Each sample ID number will be composed of these three codes in the following order: Sample location - Consecutive number - Preservative.

e.g. 2-002-A =

Pinéy River, bank just up-stream of Area 5
Second sample of project
Acidified with Nitric acid

3.3 Collection of Water Samples

Water samples will be collected from various locations throughout the site. In addition, during each sampling event field pH and conductivity measurements will be performed at each location. These procedures are outlined in section 3.4.

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3.3.1 Surface-Water Sampling Procedures

Samples collected from surface water bodies are to be collected by the following routine.

3.3.1.1 Piney River

A sample of river is to be collected at each of the six sampling stations for analysis of total dissolved iron by the following procedures.

- A. Rinse a clean sample bottle three times with water to be sampled; then collect sample. The sample bottle is to be hand held and totally submerged up stream of the person collecting the sample with the mouth of the bottle facing up stream.
- B. Rinse the Millipore polycarbonate funnel with the water to be sampled. Then rinse the polycarbonate receiving flask and polypropylene filter holder with deionized water. Shake dry.
- C. Assemble Millipore filtering apparatus using forceps to handle 0.45 micron filter paper. Attach vacuum hose to receiving flask.
- D. Pour sample from bottle into funnel and draw a vacuum on the receiving flask using hand pump. Maintain vacuum until entire sample is filtered. Immediately transfer sample to acidified sample bottle and complete sample label.
- E. Disassemble filtering unit and thoroughly rinse with deionized water. Discard filter paper.

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3.3.1.2. Other Surface Waters

During each river sampling event, two samples of the site discharge occurring at the culvert at the southeastern corner of the site will be taken. One will be for total dissolved iron and one for sulfate analysis. The samples will be collected by hand holding the bottle in the same manner as described above for the river sampling. In addition, the person sampling is to wear rubber gloves. The collection and filtering of the sample for total dissolved iron will be the same as for the river sample. For collection of sulfate sample the following procedure will be followed.

- A. Rinse the clean bottle three times with the water to be sampled.
- B. Submerge the bottle and fill completely and if possible cap under water in order to exclude air.
- C. Transfer sample to ice chest.

3.3.2 Groundwater Sampling Procedures

Groundwater samples will be collected utilizing the following procedure.

- A. Before the sampling operation begins, a water level measurement is taken using an electric water level indicator. The probe is lowered into the well until the meter needle deflects signifying contact with the water in the well. The water level measurement is taken from the top of the well casing and is measured to the nearest 100th of a foot.

B. Using either a bailer or a pump, at least four well bore volumes will be removed and discarded. In the event the well is bailed dry, a groundwater sample will be taken when the well has recovered sufficiently. Currently all the wells on site have very low yields thus well evacuation will be performed by bailing.

C. Using a bailer or pump, a sample is retrieved and used to rinse the sulfate sample bottle (unacidified) and the filtering apparatus.

D. As described above for surface waters, the filtering apparatus is assembled, and the sample is filtered and transferred to the acidified bottle.

E. A fresh sample is collected for the unacidified bottle and the bottle transferred to the ice chest.

F. The bailer and filtering apparatus are then thoroughly rinsed with deionized water.

3.4 Field Measurement of pH and Conductivity

Specific conductance and pH will be measured at each water sample collection station at the time of collection.

3.4.1 pH Meter Calibration and pH Measurement

Before each pH measurement, the meter will be calibrated using a two buffer calibration method. Based on previous studies, the waters which are going to be measured will have a pH between 2.5 and 7.0. Therefore,

buffer solutions for calibration will depend on the expected pH of the sample: 1) when the sample pH is above 4.0, buffers of pH 4.0 and 7.0 will be used; and 2) when the sample pH is below 4.0, buffers of pH 2.5 and 7.0 will be used. The buffers utilized are color coded and have known temperature compensation values. The buffers are supplied by Fisher Scientific and are guaranteed to be within 0.01 pH unit at 25° C.

The procedure for pH measurement is as follows:

- A. The buffer containers are immersed in the water to be measured for at least ten minutes for temperature equilibration. During this time the water temperature is measured using a thermometer which has previously been checked for accuracy in an ice bath.
- B. The pH electrode is then rinsed with deionized water and immersed in the 7.0-pH buffer. Using the calibration knob the meter reading is adjusted to the pH of the 7.0 buffer based on the known temperature compensation values supplied by the buffer manufacturer. For example, at a temperature of 15° C, the 7.0 buffer actually has a pH of 7.05.
- C. The electrode is then rinsed with deionized water and placed in either the 4.0 or 2.5 buffer, depending on the expected pH of the sample (see beginning paragraph of this section). The slope or temperature knob is then adjusted until the required reading is observed. If the pH of the sample is not within the expected range, then the calibration will be repeated using the appropriate buffer. For example; 2.5 buffer is used in

calibration based on expectation that sample pH will be less than 4.0, but measured sample pH is above 4.0. Therefore, repeat calibration with 4.0 buffer and remeasure sample pH.

- D. As a check of the instrument operation and calibration, the electrode is then rinsed with deionized water and the steps B and C above are repeated. If the reading is off by more than 0.02 units the calibration is repeated.
- E. The electrode is rinsed with the water to be measured and immersed in a sample bottle containing a fresh sample of the water. The sample bottle is kept partially immersed in a larger volume of sample water or the surface water body being measured to maintain a constant sample temperature.
- F. The pH reading is completed when the meter reading stabilizes. For low ionic strength waters such as is found in the Piney River, a single pH reading will take at a minimum 45 minutes, depending on the water temperature, and the condition of the electrode. The pH and the response time is then recorded. During this project, a Corning combination electrode, which is recommended for low ionic strength solutions, will be used.
- G. The electrode is then rinsed with deionized water and the calibration rechecked following steps B through D.

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3.4.2 Conductivity Meter Calibration and Specific Conductance Measurement

Before each day in the field, the conductivity meter calibration will be checked using a standard potassium chloride conductance solution (VWR Scientific, catalog no. AL51340-4, or equivalent, 0.01 M KCl). If the instrument does not read the correct value for that KCl solution at 25°C (1413 umhos/cm), a new cell constant will be calculated using the method described in Standard Methods. The method is as follows:

- A. Thoroughly rinse the electrode with a 0.01 M KCl solution.
- B. Place electrode in a beaker of fresh 0.01 M KCl solution at 25 degrees C and measure conductivity.
- C. A 0.01 M KCl solution at 25°C will have a calculated specific conductance of 1413 umhos/cm. Therefore the cell constant is equal to 1413 divided by the observed value.

Measurement procedure for specific conductivity is as follows:

- A. The conductivity cell is placed in the water to be measured. In the case of surface waters, the cell is placed directly in the water body. In the case of well waters, the cell is first rinsed with the well water which is to be measured, and then it is immersed in a fresh sample of the well water. The cell is allowed to equilibrate for several minutes.
- B. The meter is then calibrated using the internal standard. This is accomplished on this instrument (YSI Model 33) by adjusting

the red line control knob so that the meter needle deflects to the red line on the scale when the meter is in the adjustment mode. This procedure allows for the determination of the operating condition of the instrument. If the instrument cannot be red lined then corrective action is necessary.

- C. Once the instrument red line is adjusted, the reading is taken by rotating the mode knob to the conductivity scales.

The reading is then recorded in the field record book.

3.4.3 Corrective Actions

In the event that the above calibration procedures cannot be accomplished satisfactorily the following corrective actions will be taken.

- A. The batteries will be replaced with fresh batteries, and the calibration procedures will be repeated.
- B. In the case of the pH meter, if changing the batteries does not solve the problem, the back-up electrode will then be used and the calibration procedures will be repeated.
- C. If neither procedure corrects the problem, the instrument is not field repairable.

3.5 Sample Collection and Laboratory Analysis Coordination

Each sampling event is to be coordinated with the laboratory so that the samples are delivered to the laboratory within 8 hours of collection.

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Total dissolved iron and sulfate will be determined within three days of collection time. The maximum allowed holding times for sulfate is seven days and 6 months for total dissolved iron (Scalf et al., 1981).

3.6 Sample Collection Schedule

The collection of water samples will occur according to the following schedule.

3.6.1 Piney River Water Sampling

Routine sampling of the Piney River will be conducted twice monthly. In addition, river sampling will be conducted during at least one storm event which produces significant runoff into the Piney River. The Piney River will also be sampled during at least one low flow period and also for one diurnal cycle. The sampling program was initiated on May 1, 1986 and will continue for at least 120 days.

3.6.2 Groundwater Sampling

Groundwater samples will be collected from each permanent well twice during the SRI in order to sample both wet (high water table) and dry (low water table) conditions.

3.6.3 Site Runoff Sampling

The discharge from the culvert at the downstream end of the site will be collected during the routine sampling of the Piney River.

3.7 Record Keeping

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3.7.1 Field Measurement Record Keeping

A serially numbered record book will be kept of all measurements made in the field. This bound book will contain pH, temperature, specific conductance, water-level data obtained on-site during this program and time and date of measurement/sampling event at each station. Observation made during the sampling event are to be recorded and should include items such as water clarity and weather. Each page is to be initialed by the person doing the sampling. After each sampling event, a copy will be made of the appropriate pages and forwarded to the QA manager for evaluation and filing.

3.7.2 Tracking and Chain of Custody Forms

In the field, the Field Tracking Form is to be filled in completely with the appropriate information. In addition, the Chain of Custody Form and Lab Tracking Forms are to be filled out before the samples are delivered to the lab or transferred to another party for delivery to the laboratory. Each person releasing or receiving custody of the samples is to sign the Chain of Custody Form. At the laboratory, the person accepting the samples will also sign the Lab Tracking Form.

3.8 Quality Assurance Samples

Along with the regular samples collected during a single sampling event two quality assurance samples will be delivered to the laboratory. The first of these is a blank which will be prepared the day before the sampling event by adding 2 milliliters of nitric acid to a full sample

bottle of deionized water. The second quality assurance sample will be a duplicate sample collected at the same time a regular sample is being collected. The location of the duplicate will be determined the day before by the Project Manager.

4.0 SOIL AND SOLID WASTE SAMPLING

Samples of both soils and solid waste occurring at the site are to be collected for laboratory analysis. The soils analysis is primarily for determination of soil amendments needed for revegetation and for evaluation of clay deposits which may be suitable for cover material. Solid waste analysis is for determination of acid producing potential of the waste. In addition, samples of the material contained within the copperas burial pit will be collected for determination of copperas content.

4.1 Sample Container Selection and Preparation

Sampled soils and solid wastes are to be placed in new heavy (2.3 mil or thicker), approximately one liter plastic bags for shipment from the site. Dow Chemical Freezer Ziploc bags are adequate for this purpose. Each bag is to have an air-tight seal such as can be achieved when using Ziploc bags.

4.2 Sample Container Labeling

Each sample bag is to be labeled with waterproof ink with the following information:

1. Project Name,
2. Sample site identification: Boring number and general description,
3. Date of collection,
4. Depth from which sample collected,

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5. Person collecting sample, and

6. A consecutive number: First sample collected is #001.

4.3 Boring and Sampling Procedures

Samples will be collected using both a hollow-stem auger drill rig and a hand bucket auger.

4.3.1 Hollow-Stem Augered Borings

Borings 1-86 through 20-86 (Areas 1 and 3) will be completed utilizing hollow-stem, continuous-flight augering (ASTM 1586). Continuous split-spoon sampling will be performed at each location. The augers are to be advanced in two-foot increments.

Based on the reported burial pit design, it is expected that the borings which penetrate burial cells will be up to 15 feet deep. The boring depth will be varied based on actual conditions encountered at each boring location. The boring depth will be increased or decreased so as to stay within the cell bottom liner. The sampling interval will be decreased to one foot near 14 feet in depth, so that liner penetration can be avoided. The boring operation at each site will be terminated if native, undisturbed soils are encountered.

4.3.1.1 Boring Logs

The borings are to be logged by both the driller and a qualified hydrogeologist. The driller's log will describe gross subsurface detail and will include blow counts for the driving of the sampler. The logs prepared by the hydrogeologist will describe the soils encountered based

on color, texture (using U.S.D.A. classifications) and consistency. In addition, water content and other characteristics such as layering will be noted. The objective of these analyses is to identify the presence of copperas; note whether it is mixed with soil; determine its thickness; and in general terms describe the water content of the sample (ie. dry, damp, moist, wet, very wet and saturated)

4.3.1.2 Boring Locations

The hollow-stem auger borings will be emplaced in both Area 1 and 3. Figure C.4 shows the approximate locations.

4.3.1.3 Sample Collection

Samples will be collected from borings 1-86 and 2-86 in Area 3. Each soil type will be represented by at least one sample. At least one sample will be collected for every two feet of boring depth. Each soil sample core from the 1.5 inch inside diameter split-spoon will have a combined length of at least six inches. Sampling intervals will be noted on the boring log.

For borings 3-86 through 20-86, within the approximate boundaries of the copperas burial pit, the sampling will be restricted to collection of soils visually suspected of containing copperas. Boring number 10-86 will be sampled in its entirety in order to determine to what degree subsidence will continue to occur in that vicinity. All soils recovered by the split spoon from this boring will be collected for analysis. For each of the remaining borings, at least one representative sample of the copperas contaminated soil will be collected. This sample will be

selected based on color and texture as representing the waste in that boring. It is suspected that through the burial operation sufficient mixing occurred so as to homogenize much of the waste/soil mixture.

4.3.1.4 Equipment Decontamination

Under very rigorous sampling conditions, the drilling equipment including the complete truck, augers and sampling equipment would be thoroughly cleaned at the completion of each hole. However, cross contamination between holes under this drilling program is not a problem. The object of this sampling program is not to identify trace quantities of contaminants. In addition, the borings will all be conducted within a known area of contamination, thus, contaminants will not be transferred to uncontaminated areas.

Before the drilling rig leaves the site, contaminated soils will be scraped from the augers. The nonhazardous nature of the existing contamination does not warrant a more stringent decontamination program.

4.3.2 Hand-Augered Borings

In order to collect soil and solid waste samples from Areas 1, 2, 3, 4, and 6, a 3-inch diameter hand bucket auger will be used according to ASTM method ASTM 1452. Some of the samples will be analyzed for pH and nutrient parameters by the Virginia Cooperative Extension Service labs in Blacksburg, Virginia. These results are necessary for the design of any revegetation programs for denuded areas. Samples of the solid waste contained in Areas 4 and 6 will be collected and analyzed for acid producing potential.

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In addition, hand-augered borings will be utilized to explore the immediate subsurface of Area 3 for pockets of copperas waste (see Figure 4.1 for locations).

4.3.2.1 Sample Collection for Soils Analysis

Soils in Areas 1, 2 and 3 are to be sampled for analysis of nutrients and pH as a means for determining the revegetation requirements. The approximate boring locations are shown in Figures C.4 and C.5. These locations were selected because they represented both vegetated and unvegetated areas. The main thrust of this activity is to determine the requirements for the revegetation of the denuded areas.

The auger is to be advanced and its contents transferred to a sample bag (described in Section 4.1 above) until a depth of one foot is reached. The entire volume of sample is to be collected.

4.3.2.2 Sample Collection of Solid Wastes

Samples of the solid waste contained in Areas 4 and 6 will be obtained for analysis of their acid-producing potential. The locations of these borings is found in Figure C.6.

The samples are to be collected using a hand bucket auger. In each area the auger is to be advanced to a depth of six feet and the entire sample collected for later laboratory reduction and analysis.

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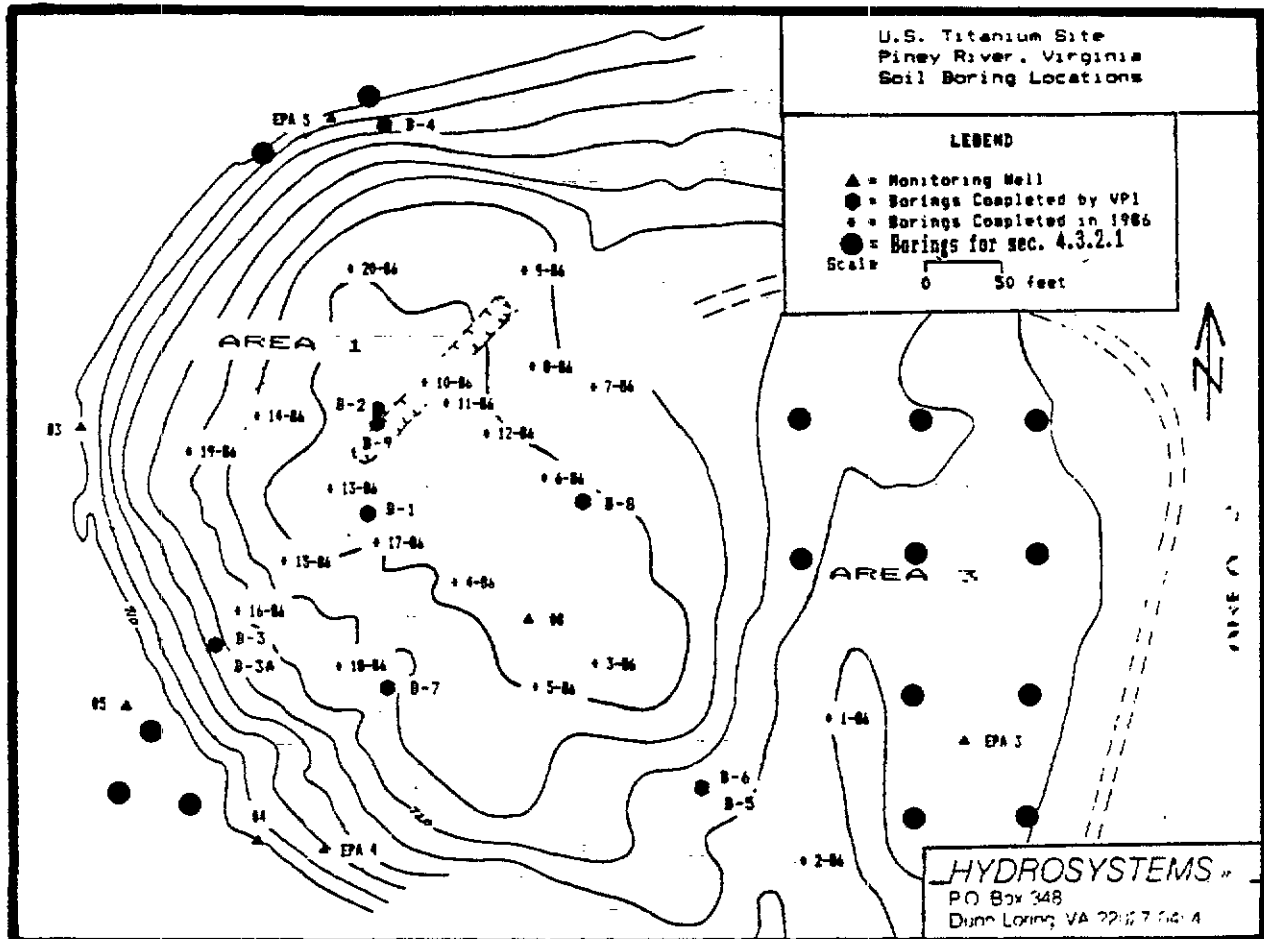


Figure C.4. Map showing locations of borings in Areas 1 and 3 at the U.S. Titanium Site.

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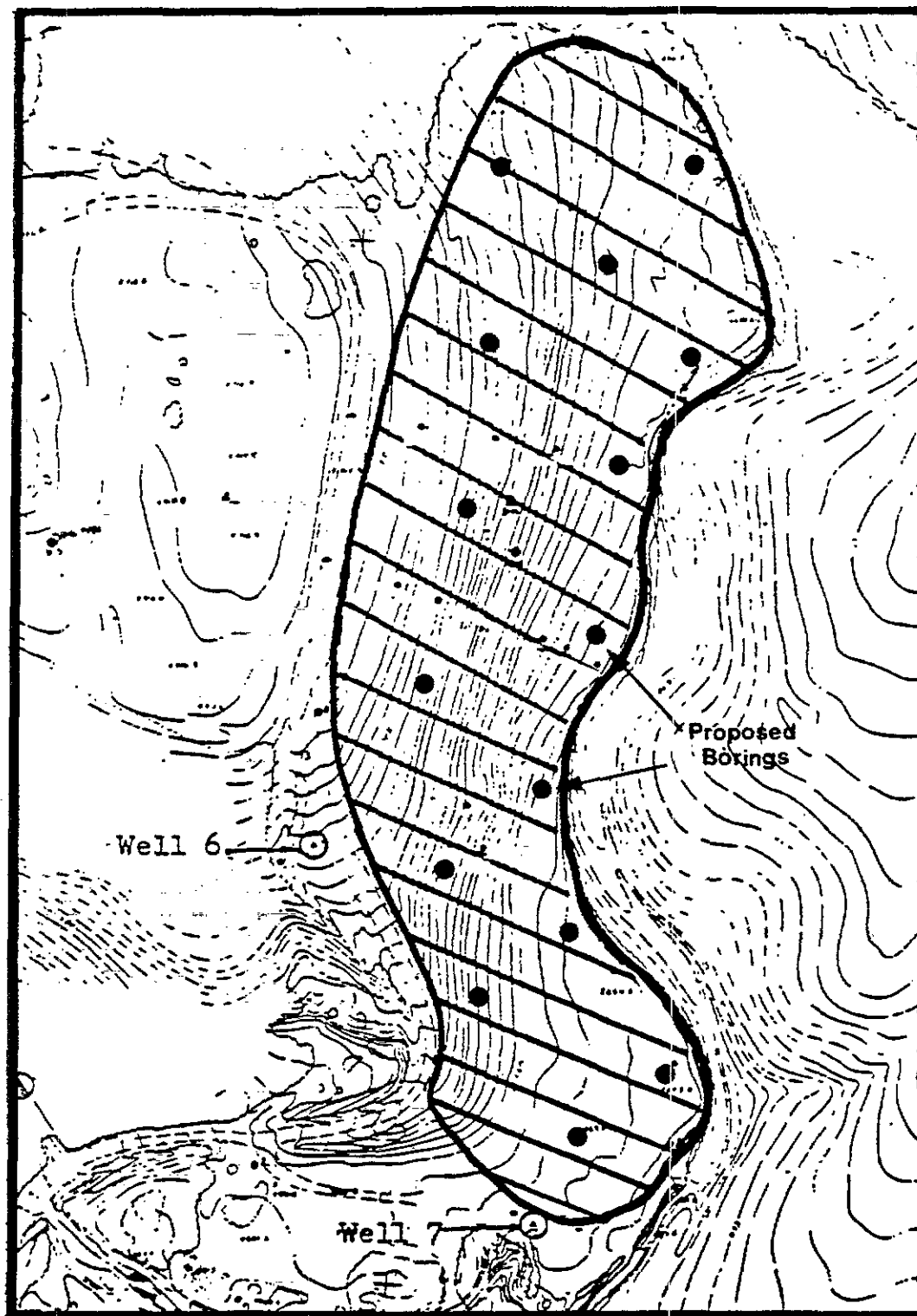


Figure C.5. Map showing locations of borings in Area 2 at the U.S. Titanium Site.

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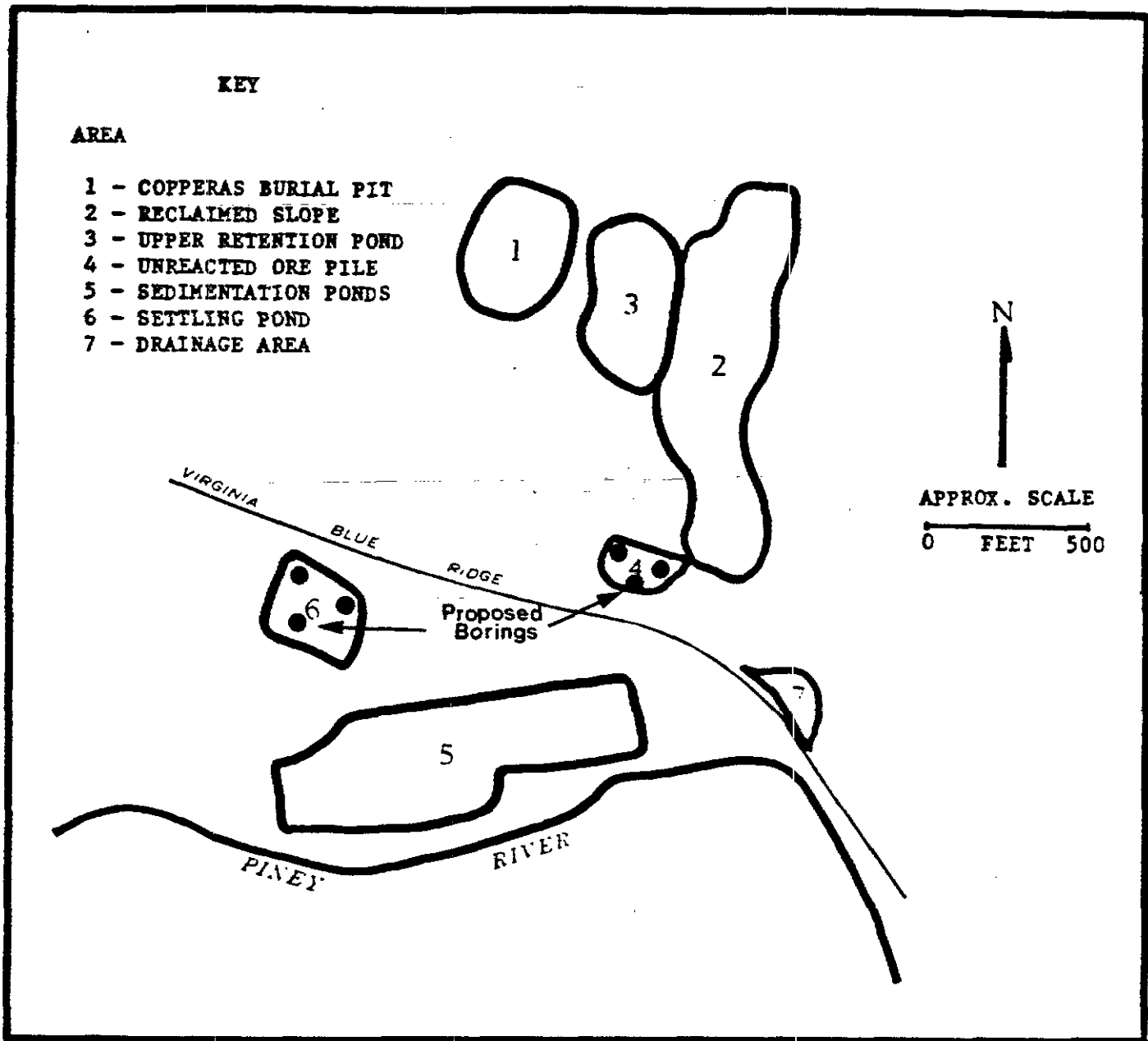


Figure C.6. Map showing locations of borings in Areas 4 and 6 at the U.S. Titanium Site.

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4.3.2.3 Sample Collection for Copperas Content Analysis

In Area 3, ten hand borings will be utilized to investigate the possible occurrences of pockets of pure copperas. In addition, these same borings will be utilized for the collection of surficial soils for nutrient analysis. The top foot of each boring will be sampled for this purpose. The hand auger will be advanced and soils retrieved visually examined for copperas. Samples suspected of containing copperas will be bagged and sent to the laboratory for analysis. The remainder of the soil retrieved from each boring will be discarded.

4.3.2.4 Equipment Decontamination

Since trace contamination sampling is not the objective of this program, and the known contamination at the site is nonhazardous, decontamination of the hand boring equipment will be minimal. After each boring, the auger is to be scraped clean or rinsed with clean water.

4.4 Record Keeping

As is the case for water sampling, detailed records of soil and waste sampling is necessary. Chain of Custody and Tracking forms are to be completed for sampling event. Field activities will also be detailed in a field record book.

4.5 Quality Assurance Samples

A split sample of at least one sample collected during a single sampling event will be sent to the laboratory for analysis.

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5.0 REFERENCES

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